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WWF

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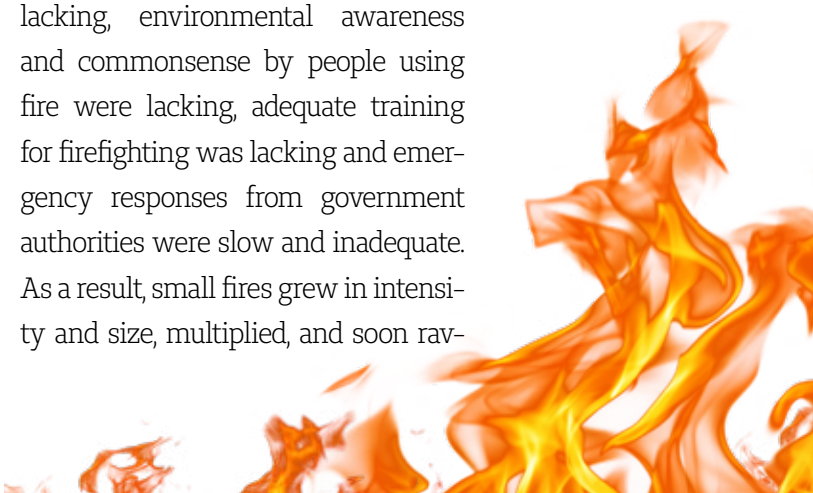
SOLIDARITY AND COMMITMENT

The Pantanal asked for water. The land of the rivers, lakes, oxbows, soda lakes and annual flood cycles slowly dried up over two consecutive years of drought. Combustible organic matter built up in the dry pastures, forest patches, dried out lakes and in floodplains that were usually inundated. Unfortunate careless behavior by some inhabitants started the fires that rapidly raged across the Pantanal. Innumerable wild animals were killed or injured. Predation and scavenging became common. Many survivors still faced hunger and thirst, competing with each other for food that was not scorched by fires, and for remaining water found in the larger lakes.

It is true that the Pantanal biome evolved with the presence of fires. Many ecological processes are triggered by fire, such as the flowering and fruiting of certain trees, including the famous paratudos (trumpet trees, genus *Tabebuia*), or the germination of *carandá* palm seeds (*Copernicia alba*) that are dormant in the soil until fire arrives. There are many plant species that developed protections against flames. For example, some have thick bark or roots capable of sprouting through the ashes. Among the animals, many species are able to escape or seek refuge in underground burrows, natural tree cavities or aquatic habitats.

These strategies generally work during periodic fires of moderate intensity, whether natural, started by lightning or human-caused. However, this was not the case in 2019 and 2020. Although the prolonged drought was within the range of climatic extremes recorded in the Pantanal, measures to control the accumulation of highly-combustible vegetation were lacking, environmental awareness and commonsense by people using fire were lacking, adequate training for firefighting was lacking and emergency responses from government authorities were slow and inadequate. As a result, small fires grew in intensity and size, multiplied, and soon rav-



aged and spread across the landscape. Firefighters, few in number, struggled to reach inaccessible fire stricken areas that did not have roads, electricity or an adequate communication system.

Researchers, volunteers, community members, local governments and non-governmental organizations have come together to put out the flames and try to minimize biodiversity losses. WWF-Brazil supported numerous initiatives to organize fire brigades on ranches and in Pantanal communities, providing firefighting gear and personal protective equipment to firefighters. They provided funds for setting up emergency rescue centers to treat injured animals in the field, and they donated medication and veterinarian supplies to rescue and rehabilitation centers (e.g., CRAS in Campo Grande, Mato Grosso do Sul). WWF-Paraguay and WWF-Bolivia set up an international communication network to exchange information about wildfire movements along the borders of the three countries.

This edition of the magazine presents one of the first assessments of fire impacts and the long-term consequences that will affect the Pantanal over the coming years. There is also an encouraging report of resilience, as in the case of hyacinth macaws, whose nests were impacted by fire during the peak of their reproductive season at Caiman Ecological Refuge and at Fazenda São Francisco do Perigara in 2019 and 2020, respectively. WWF-Brazil provided emergency aid to implement nest protection measures for the new generation of surviving hyacinth macaws.

In this edition of Pantanal Science, the ecological functions of pollinators and their intricate networks of plant-pollinator interactions are presented. Although they are small, even insects can play an important role in the restoration of the Pantanal. Another article discusses parasitism, emphasizing the importance of considering the health of both domestic animals and wildlife as one. The role of herbivorous mammals - true environmental guardians, capable of providing conservation tips for dealing with ongoing land-use changes - is also described. This edition also reports on the predator-prey relationships of ocelots, one of the most abundant feline species in the Pantanal.

With a desire to get back to normal - in the face of wildfires and the COVID-19 pandemic - it is important to provide examples of sustainable businesses being developed in the region and present a 20-year commemoration of the Fishes of Bonito Project, connecting science, communities and tourism. More than ever, this is a time to value traditional customs and knowledge - such as the use of *Pantaneiro* horses for handling cattle, and the use of edible native plants that enrich *Pantaneiro* diets - among other ongoing initiatives. In this edition, ecological economic zoning instruments for participative territorial planning and landscape change scenario projections are not forgotten. Territorial planning reconciles economic growth and protection of natural resources, favoring current and future generations, while landscape scenario projections allow us to plan a future that incorporates the wishes of all *Pantaneiros*.

Through the array of subjects covered in this edition, WWF-Brasil reiterates its commitment to conservation of the vast biodiversity in the Pantanal and the surrounding highlands. And their belief in solidarity without borders. Together we can face the challenges and prioritize environmental actions that guarantee the resilience of the Pantanal ecosystem!

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SUMMARY

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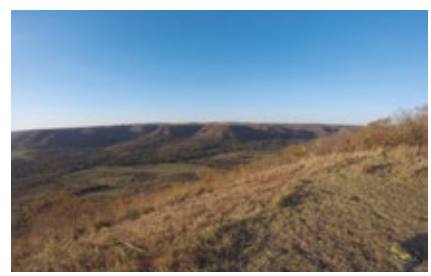

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Photo: Geraldo Alves Damasceno

ETHNOBOTANY

THE KNOWLEDGE AND FLAVOR OF NATURAL BIOCULTURAL ORCHARDS

Edible native plants enrich the diet of Pantanal residents and visitors, and valuing traditional knowledge contributes to preservation of species and their multiple uses

BY IEDA MARIA BORTOLOTTO AND GERALDO ALVES DAMASCENO-JUNIOR

People of various indigenous ethnicities live in the Pantanal, along with riverine and quilombola communities, rural producers, farmers and other groups, who may or may not be considered traditional *Pantaneiros* (i.e., people of the Pantanal). This region in the central portion of South America stands out because of its rich cultural heritage that extends beyond the international boundaries of four countries: Brazil, Bolivia, Paraguay and Argentina. A rich biological diversity is associated with the region's cultural diversity, including plants common to the Pantanal and to neighboring biomes: Cerrado, Chaco, Amazon Forest and Atlantic Forest. Some of the species are well known, used and even cultivated by the local populations, together with exotic plants, in small domestic gardens or fields.

The exact number of native food plants that occur within the international limits of the Pantanal is not known, nor are there systematic studies in the Brazilian portion on the traditional knowledge associated with the plants. Until the mid-1980s, the attention of scholars was concentrated mainly on records of wild food plants included in the diets of indigenous populations. However, since the 1990s, studies have expanded to include non-indigenous communities


Photo: Cyntia Santos

Acuri

through species collection surveys, identification of plants with known uses and deposits of specimens in herbaria.

A preliminary list for the entire state of Mato Grosso do Sul, Brazil, developed by a team of researchers from the Federal University of Mato Grosso do Sul (UFMS) estimated that there are 294 species of native plants that can potentially be used for food. Among these, more than 100 occur in the Pantanal, one of the world's largest inland floodplains whose waters are drained by the Paraguay River.

Several food species are abundant among the vegetation physiognomies native to the Pantanal, both in flooded and non-flooded areas. Many of them occur in vegetation formations dominated by a single species (monodominant), forming true natural "orchards" with fruits, nuts, hearts of palm and other edible parts. Such occurrences contribute to the cultures of local human populations: they are biocultural orchards.

Some of the main results from ethnobotanical studies carried out in communities located along the Paraguay River during the last two decades include scientific publications and community extension actions focused on valuing culturally important plants. These include wild food plants that are known and used by local people.

The data for these studies were obtained from interviews with adult residents of the communities, accompanied by botanical collections in the municipalities of Corumbá and Porto Murtinho, Mato Grosso do Sul. In Corumbá, residents from the Albuquerque, Castelo, Amolar and Guató (indigenous) rural communities participated. In Porto Murtinho, the studies included inhabitants of rural and urban areas located along the banks of the Paraguay River.

The interviewees demonstrated knowledge about the use of 69 wild plant species for making oils and flours, or preparing dishes and drinks that make up part of their diet. Among the drinks, teas, juices and "*chichas*" were mentioned; the latter being a local name for

Photo: Ieda Bortolotto

Photo: Paulo Robson de Souza

"Laranjinha-de-pacu" (above), "bocaiúva" flour (right) and "carandá" (next page) enrich the diet of *pantaneiros* and visitors

artisanal fermented beverages similar to beer.

Among the most important species of native food plants, palm trees predominate: "bocaiuva" (*Acrocomia aculeata*), for its oil, pulp, heart of palm and flour, and "carandá" (*Copernicia alba*), for its edible fruits, although they are under appreciated and seldom consumed. What gives these plants their cultural value is the wealth of associated knowledge and practices that are maintained by local communities. In addition to providing food, these plants have medicinal, aromatic and timber-related uses; they serve as fish bait and are used in religious rituals. For centuries, traditional populations have maintained the practices of extractivism and consumption of these wild food plants, passing down knowledge about them orally from generation to generation.

However, despite the local importance of some plant species, traditional knowledge about them is in the process of eroding, or it has been lost. This is the case for wild rice (*Oryza* spp.), whose use by indigenous peoples has several records in historical literature, but cultivation and even harvesting are no longer practiced. Also, the practices of obtaining a variety of oils, drinks and flours from the wild rice were mentioned in interviews as "ways of the past", and today the practices are mainly known only to elderly community members.

In Corumbá, for communities farthest from urban centers, the number of native food plants known and used is greater than those known and used in communities closer to cities. This shows how proximity to commercial markets influences and reduces the use of wild plant species. There are also plants whose medicinal use is more important than its value as a food, as is the case for "jatobá" (*Hymenaea* spp.) used by the riverine communities along the Paraguay River.

Even so, there are still well-preserved areas with plenty of native food plant resources that enrich *Pantaneiro* diets.

There are also still communities with a wealth of knowledge about native plants. Not to mention, there is potential for communities to gain economically from marketing food plants, especially abundant species, such as those found in monodominant vegetation formations. So, with the objectives of: valuing food plants; encouraging the conservation and sustainable use of wild plant species and stimulating the generation of income to improve the quality of life in the communities, several actions were proposed and developed within the scope of the "Programa Sabores" (Flavors Program).

"Programa Sabores" is a UFMS community extension program with the objective of "Valuing Food Plants from the Pantanal and Cerrado". Program activities are developed in collaboration with several rural community partners, including schools. Culinary workshops are organized, producing dishes and drinks from recipes developed by the communities or by the extension team. With the idea of incentivizing consumption and commercialization, workshops are offered on good hygiene practices, harvesting and post-harvesting techniques, guidance on the nutritional value of fruits and others. Program activities have extended beyond the communities where the research was carried out and have included 14 municipalities in the Cerrado/Pantanal region during the period from 2006 to 2020.

Photo: Rosa Helena da Silva

Annually, "Programa Sabores" promotes a course on food plants native to the Pantanal and Cerrado and counts on the participation of students and residents from regional communities. The extension team also created a set of products in collaboration with the communities, such as a cookbook, postcards and calendars. These products are free of charge and are distributed to workshop and course participants.

With the support of these extension program actions, residents of traditional communities are already producing and selling frozen pulps, jellies, flours, oils and other food products. Among the abundant plants involved in actions to incentivize use by the communities, "bocaiuva" (*Acrocomia* spp.), wild rice (*Oryza* spp.), "acuri" (*Attalea phalerata*) and "laranjinha-de-pacu" (*Pouteria glomerata*) are prominent. There are several governmental and non-governmental institutions implementing projects to strengthen and organize communities and support extractive activities.

The ability of *Pantaneiros* to rescue neglected practices and knowledge that still exists within their communities has advanced the specialized use of edible plants in recent years. It has also progressed due to the willingness of communities, and especially women, to take control of their activities by organizing and investing in autonomy. The conservation of wild food species and the maintenance of traditional knowledge are fundamental to sovereignty and the food and nutritional security of Pantanal communities. And, it will ensure that fundamental resources remain abundant for native fauna.

THE *PANTANEIRO*, A HORSE OF EXTRAORDINARY VALUE

Unique multifunctional breed adapted to environmental extremes; excellent performance handling livestock, providing transportation, giving tourists horseback rides and competing in sporting events

BY SANDRA APARECIDA SANTOS AND FÁBIO TAKAHASHI

Hearty, tough and resilient, *Pantaneiro* horses are ideally adapted for handling cattle, whether during the peaks of the flood and dry seasons, or during any of the nuanced conditions that appear mid-cycle between seasonal peaks. A descendent of equines brought from the Iberian Peninsula to Brazil during the colonization period, the horse has undergone centuries of adaptation in a dynamic and complex environment with extreme temperatures. It was recognized as a unique breed in 1972 when the Brazilian Association of *Pantaneiro* Horse Breeders (ABCCP) was created in Poconé, Mato Grosso with the fundamental aims of promotion, selection and improvement of the breed.

Valuable genetic traits acquired during the long process of natural selection gave the *Pantaneiro* horse the exceptional characteristics of adaptability, toughness and functionality. They are animals that are resistant to diseases and even thrive in areas subjected to limited resources and environmental disturbances (episodic or persistent). They tolerate heat as well as drought; traverse areas with dense vegetation; approach a majority of wild animals calmly; their hooves resist humidity during long rides through wetlands, and they are able to find forage and sustain themselves for long periods in flooded environments.

These characteristics make the *Pantaneiro* horse a generalist and multifunctional animal, able to live and work in a wide variety of environments and cattle production systems. To maintain this adaptability, it is

Photo: Sandra Santos

necessary to ensure the genetic stability and diversity of the breed through appropriate conservation, selection and breeding management.

Bred semi-extensively among large rural properties, the *Pantaneiro* horse is economically important in the Pantanal. It is essential for handling cattle; is one of the principal means of transportation for local populations (especially during flood periods) and is seen as a symbol of local culture to visitors of the Pantanal. On ranches with tourism operations offering horseback and trail riding, they have even greater value for demonstrating how traditional cattle ranching can be practiced in harmony with biodiversity.

Because of their versatility and functional characteristics, the *Pantaneiro* horse has attracted buyers from a variety of regions in Brazil, mainly for their utility in handling cattle, but also for other activities, like equotherapy, trail rides and sporting events. The *Pantaneiro* horse's agility and its ability to read cattle, i.e., its "cow sense", has encouraged its inclusion in equestrian competitions, most prominently in Technical Lassoing, Long Lassoing, Team Penning (separation of certain cows from the herd) and Ranch Sorting (selection and direction of cattle to pens/corrals), among others.

One important factor in these competitions is the interaction between horse and rider, a relationship of trust developed during training and also during free time and daily care of the animals. Inclusion of the breed in sporting events encourages family participation – especially

Photo: Sandra Santos

by young adults and children – and it helps guarantee continuity, promoting the conservation of the breed for future generations. To reinforce the functional value of the *Pantaneiro* horse in sporting events, their participation should be promoted through sponsorships.

In the Pantanal, the horse is especially important for handling cattle when flooding occurs, as it is one of the few breeds to have humidity resistant hooves. This valuable service is appreciated more by ranchers who insist on registering their animals with the ABCCP. However, it should be appreciated more widely by ranchers in the region, because it is a breed that is easy to care for and requires few purchased external supplies for it upkeep.

Pantaneiro horses feed mainly on native forage species, which are highly-sustainable renewable resources in the region. This is because the growth of native pastures does not require fossil fuel inputs. The animals of this extraordinary breed also maintain the habit of consuming aquatic plants, such as the water lily (*Nymphaea gardneriana*), taking advantage of the Pantanal's diverse floral resources.

In order to adequately appreciate the functional work of the *Pantaneiro* horse, it is useful to carry out an emergetic analysis, a systems-level procedure that assesses the energy required to perform a service – in this case, handling cattle – through quantification of the contributions from natural capital and external supplies in the performance of the service.

For such this analysis, it was first necessary to define a production system, with its energy input and output flows. The 100 hectares fenced study area in the Pantanal was comprised of sections of forest, cerrado (a more open forest formation) and

savanna with approximately 30% consisting of native pasture. The area held 17 *Pantaneiro* service horses. Native forage species that only require the sun, rain and soil nutrients (a renewable resource in the Pantanal) to grow were the main sources of food for the animals (an example of provisioning ecosystem services). The only external supplies and services needed for the study consisted of vaccines, medications, tools, fencing and labor. The service provided (handling cattle) could have internal (management unit/farm) or external (commercialization) output flows.

Based on the analysis of energy inputs and outputs from the study area, it was possible to estimate several emergetic indices. One is the renewability index, that is, the relationship between renewable energy and total energy, which provides an estimate of the sustainability of the service. In this case study, renewability was 64%. In other words, for the semi-extensive production system that we evaluated, the horses primarily used natural resources, transforming native forage species into a functional service (handling cattle). Of course, renewability depends on the type of production system used to maintain the horses and will be affected by factors like the proportional use of native pasture, or other supplies and services.

Another index that we estimated was the quantification of the service, in "emergy dollars" per hectare. In monetary terms, the value of the cattle handling service performed by a *Pantaneiro* horse was 603.53 emergy dollars per hectare/year. This estimate included only cattle handling, while in reality, *Pantaneiro* horses also provide many other services, such as transportation, tourism support and leisure.

Results show the extraordinary value of the functional services provided by *Pantaneiro* horses maintained on native pasture by rural producers. Undoubtedly, assessing the value of these services will contribute to quantification of green technology benefits associated with sustainable ranching systems.

Useful for handling livestock (bottom left), even in flooded areas (previous page), the *Pantaneiro* horse (bottom) is also a good option in transport, tourism, leisure and in competitions

Photo: Sandra Santos

Photo: Sandra Santos

OCELOT, BIG OCELOT, WILD CAT OR LITTLE JAGUAR?

Discover the most common species of "spotted cat" in the Pantanal and its strong influence on prey and other small felines

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Common names of wild animals tend to be different regionally within a country, and even locally within a region. The most obvious exception is for "spotted" cats. Even though there are six distinct species in Brazil, they are often given the same generic common names throughout the country. It doesn't matter if you're talking about the smallest species – the oncilla or southern tigrina – weighing on average just 2.5 kg, or the largest species – the jaguar that weighs up to 120 kg (almost 50 times more). In Brazil, they are all called ocelot, big ocelot, wild cat or little jaguar, generalizations that are capable of generating confusion when identifying the species, especially during interviews of local residents for preliminary assessments on the occurrence of these animals in particular ecosystems.

The use of these names, in fact, seems to obey criteria related to size: if the animal is not big enough to be a jaguar, it is called a big ocelot or a little jaguar. If it is a bit smaller, it is called a ocelot. And wild cat (or forest cat) is used for any cat with a spotted coat seen at a glance amid the vegetation.

To complicate matters, natural variation in size occurs among adult individuals of the same species. The ocelot (*Leopardus pardalis*) is the third largest feline species in Brazil after the jaguar (*Panthera onca*) and puma (*Puma concolor*). An adult individual can measure between 1 to 1.4 meters in length from the tip of the snout to the tip of the tail, while its weight can vary from 8 to 16 kg! There are also differences between the sexes, males being, on average, 25% larger than females. Therefore, it is easy to understand when there is skepticism about species sightings or confusion related to common names.

Foto: Felipe Peters

The ocelot is the third largest feline in Brazil after the jaguar (bottom right) and the puma (bottom left)

Foto: Adriano Gambarini

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The ocelot is widely distributed in Brazil and in the Pantanal. It is one of the most commonly sighted feline species and, possibly, the most abundant, both on the Pantanal floodplain and in the bordering *Cerrado* highlands. One of the most likely explanations for its abundance is its intermediate size, which increases the ocelot's ability to adapt to different situations. Ocelots hunt small mammals, birds, lizards, snakes and fish, but they also catch medium-sized prey such as agoutis, pacas and armadillos. They occasionally feed on animals larger than themselves, such as gray brocket deer or greater rheas. These feeding habits may avoid intense disputes with jaguars over food, while alleviating competition for food with smaller feline species. According to several studies, even in areas where jaguars are abundant, ocelots are present, often in high numbers. However, where ocelots are abundant, smaller "spotted" cat species typically occur in low numbers, or may be absent.

The phenomenon of ocelots "bullying" smaller feline species has been termed the "parda-

lis effect", highlighting the idea that ocelots are dominant over smaller cats. This dominance may be one of the most important ecological forces structuring communities of medium-sized predators and their prey.

Felines are obligate carnivores, that is, they feed exclusively on other animals. Therefore, during their prey searches, greater competition with other carnivores is expected. The more "similar" the carnivores are, the greater the competition should be. In simple terms, the largest species dominate the environment (and prey supplies) to the detriment of the smallest: where jaguars are abundant, pumas are less common, and where jaguars are less common or absent, pumas are more abundant. However, neither of the two larger cat species appears to have a significant impact on the ocelot, whose variation in abundance appears to be much more related to the availability of prey, rather than to the presence of the larger felines. In contrast, the impact of ocelots on smaller feline species is quite evident: where ocelots are abundant, smaller cats are less common.

This is especially true for small "spotted" cats: margay (*Leopardus wiedii*), southern tigrina (*Leopardus guttulus*), little spotted cat (*Leopardus tigrinus*) and Geoffroy's cat (*Leopardus geoffroyi*), while this effect is less pronounced for small cats that are not spotted, like the Pantanal cat (*Leopardus braccatus* and *L. munoai*) and the jaguarundi (*Puma yagouaroundi*). Spotted coat patterns are usually associated with cats inhabiting forested habitats, serving as camouflage among the vegetation while facilitating prey searches and predator avoidance.

Foto: Felipe Peters

Foto: Felipe Peters

All of the smaller "spotted" cat species preferentially inhabit forests and are active at night, so they come under the influence of the "*pardalis* effect". The jaguarundi is also a forest dependent species, but it is active during the daytime. Pantanal cats frequent open areas, like native grasslands and wetlands, seldom using forested environments. So, these two "unspotted" felines are able to avoid the "*pardalis* effect", either by being active when ocelots are not, or by inhabiting environments that are seldom used by the ocelots.

The ocelot plays a fundamental role in terrestrial ecosystems that make up the mosaic of environments in the Pantanal: including wetland margins, forests and savannahs. Its presence is vital for

Foto: Adriano Gambarini

If the ocelot is abundant, there are fewer small cats, such as the margay (previous page top); the jaguarundi (left); the Geoffroy's cat (previous page bottom); the southern tigrina (below), and the Pantanal cat (bottom)

Foto: Felipe Peters

Foto: Felipe Peters

maintaining the dynamics of ecological processes through its interactions with a huge diversity of prey, larger predators and a range of competitors.

The conservation status of the ocelot in the Pantanal has not yet been systematically assessed. But, overall, the environmental health of the Pantanal is better than it is for neighboring biomes, such as the *Cerrado* and Atlantic Forest. Therefore, it is likely that the conservation status of the ocelot is also better in the Pantanal. For long-term conservation purposes, ocelot populations will depend on the maintenance of remaining forests fragments in the bordering Cerrado highlands and especially on riparian corridors that accompany rivers and other aquatic environments in the Upper Paraguay River Basin (BAP). Ocelots are able to range and hunt in a variety of native vegetation formations, as well as in cultivated areas, but they predominantly use forested habitats.

Based on a large number of recurring ocelot records that were documented on a ranch with cattle and tourism activities in the Rio Miranda region of the Pantanal, the site was chosen for launching the Ocelot Project. Initially, studies focused on the diet and local occurrence of the species. These studies

Foto: Érica Gomes

Foto: Érica Gomes

lasted two years (2002 to 2004) and contributed to a Master's degree awarded by the Federal University of Mato Grosso do Sul (UFMS). A surprising result from the study was that numerous sightings of ocelot individuals were registered in irrigated rice fields, which, previous to the study, were considered inhospitable habitats for a forest associated species. In a little over a year during 103 nocturnal wildlife surveys, there were 81 records of ocelots (79%). Studies of their diet revealed that 80% of the items found in ocelot feces were small rodent remains. This led to the hypothesis that the rice fields were providing an abundant source of rodents for the ocelots.

In 2004, after the initial studies were completed, the Ocelot Project continued to document records of the species through photographs, videos and direct observations. Starting in 2005, the ranch's team of local guides began filling out faunal observation forms after nocturnal safaris to observe wildlife (initiated in 1996). The data collected by these citizen scientists between 2005 and 2018 showed the same trends for ocelots observed during the 2002-2004 UFMS study.

After completing these studies, the project began to focus on new questions. Are the high numbers of ocelot sightings due to the presence of many individuals (i.e., a high density population), or to repeated observations of a few ocelots that are acclimated to presence of humans? If the density of ocelots is high in the agricultural portions of the landscape, is this due to the abundance of small rodents in rice fields, or is this also related to the proximity of native vegetation remnants on which the species depends? For long-lived carnivorous mammals with large ranges – like ocelots and crab-eating foxes (*Cerdocyon thous*) – can landscape-level changes in the Pantanal affect their health? Can these changes, for example, alter ecological interactions between hosts and parasites?

To answer these questions, new field activities with complementary objectives were launched. The population size of ocelots was estimated based on annual camera-trap samples obtained at 45 to 60 locations distributed among the range of different environments on the ranch, including rice fields, livestock areas and natural habitats. Thanks to the unique fur coat patterns of each ocelot – similar to a "fingerprint" – it is possible to identify individuals from camera-trap photos and estimate the total number of animals in an area (population

density) using mathematical models. In addition, the same mathematical models can be used, for example, to examine relationships between differences in the number of individuals registered in different environments with the number of available prey.

Using the database of photos and direct observations obtained over the last 15 years, at least 65 different ocelots were identified in the study region, some over consecutive years. In fact, one of the females remained in the same area from 2006 until the most recent survey in 2019. Long-term data like these are very important and require continuous field sampling efforts. These data can be used to evaluate parameters other than population size, such as survival, longevity, birth and mortality.

Preliminary analyses of project data show that the population density of ocelots is between 29 and 66 individuals per 100 km^2 (10,000 hectares). This estimate is consistent with the hypothesis that a large population inhabits the study region. For future analyses, these estimates will be refined (to reduce uncertainty in the results), and both the effect of prey abundance and spatial variation among environments will be evaluated.

In addition to information collected about ocelots, the camera-trap data was used to carry out a systematic survey of medium- to large-sized mammals in the area, helping us understand how other species use the available environments. During two consecutive years of camera-trap monitoring, 3,400 photos of 26 wild mammal species were recorded. Only 5 species were responsible for 70% of the records: ocelot (591 images), marsh deer (*Blastocerus dichotomus*, 551), capybara (*Hydrochoerus hydrochaeris*, 470), jaguar (393) and crab-eating fox (375).

More recently, live trapping was used to investigate the potential prey of ocelots. The live traps were distributed among multiple locations in agricultural and native habitat areas. The small mammals captured were sedated, measured, weighed and biological samples were collected. Small metallic earrings for identification were also placed on the captured animals before they were released. Similar to the camera trap analyses, based on the number of captures and recaptures of different individuals and species, mathematical models were used to estimate population densities and species abundances in the sampling areas.

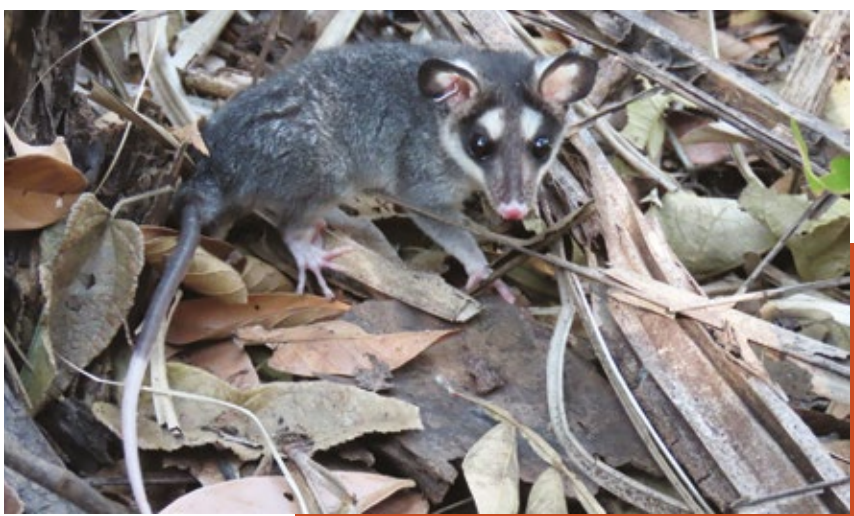


Foto: Érica Gomes

Most common ocelot prey: Chacoan marsh rat (previous page left), agile gracile opossum (previous page right) and gray four-eyed opossum (left)

From a total sampling effort of 9,480 trap-nights, 314 individuals from 9 species were registered. Two of the species stood out in terms of abundance, representing more than 55% of the total registered individuals:

the Chacoan marsh rat (*Holochilus chacarius*) and the agile gracile opossum (*Gracilinanus agilis*). The other species registered were the mamore arboreal rice rat (*Oecomys mamorae*), the Cerrado climbing mouse (*Rhipidomys macrurus*), the hairy-tailed bolo mouse (*Necromys lasiurus*), the gray four-eyed opossum (*Philander opossum*), the Brazilian guinea pig (*Cavia aperea*), Agricola's gracile opossum (*Cryptonanus agricolai*) and a rodent of the genus Cerradomys.

In some rice field plots, the live-trap capture success rate reached 11%, meaning that for every 100 traps placed daily, 11 animals were captured! For comparison, in the Atlantic Forest, the capture rate for small mammals typically varies between 1.5% and 3%, that is, on average, only 2 to 3 individuals are captured per 100 traps.

Although a number of the small mammal species were registered in both the rice fields and in native vegetation habitats, the Chacoan marsh rat was more abundant in the rice fields, while the agile gracile opossum predominated in native vegetation habitats. So, the Chacoan marsh rat is an ideal prey for ocelots in rice fields due to their high availability (many individuals) and their size (average adult weight between 115 g and 150 g). In native habitat areas on the ranch, a more varied diet of abundant lower-weight small mammals was available: about 30 g for the agile gracile opossum and 70 g for the mamore arboreal rice rat. In these native areas, other species may be preyed upon more frequently, such as the gray four-eyed opossum (average weight 300 g), Azara's agouti (*Dasyprocta azarae,* 3 kg), the spotted paca (*Cuniculus paca*, 7.5 kg), in addition to ground birds, such as the undulated tinamou (*Crypturellus undulatus*, 800 g) and the bare-faced curassow (*Crax fasciolata*, 3 kg), all of which were recorded frequently in camera traps.

For investigations of ocelot and other wildlife health, field procedures included capturing and anesthetizing of medium-sized carnivores for biometric measurements, clinical examinations and collection of biological samples, i.e., blood, hair and ticks. During the procedures, captured animals were hydrated and allowed to recover from anesthetic effects in shaded traps. After complete recovery, they were released at the same site where they were captured. Of 13 captured ocelots, four were adult males (average weight: 12.3 kg) and seven were adult females (9.4 kg). A large

HEALTH ISSUES

Most of the ocelots and crab-eating foxes captured for biomedical collections by the Ocelot Project presented clinical symptoms, such as dehydration, anemia and low body scores (i.e., an evaluation of fat and muscles indicating an animal's energy reserves). Fourteen of the 20 hemoparasites investigated were detected in one individual animal, and at least two of the parasites were detected in all of the rest of the individuals evaluated. On average, ocelots were infected by 6.7 hemoparasites per animal. Infections of crab-eating foxes were lower at 4.3 hemoparasites per animal.

Among the hemoparasites detected, it is worth highlighting those with significant health implications – for wildlife, domestic animals or humans – such as the rabies virus and the bacteria that causes leptospirosis (whose main urban hosts are rodents). All the car-

female cub and a young nearly-adult male were also caught. Among the 12 crab-eating foxes captured, there were 5 adults (3 males with an average weight of 9.4 kg and 2 females with an average weight of 6.3 kg), four sub-adults (3 males and 1 female) and 3 kits (2 males and 1 female).

For the captured carnivores, 20 parasites that circulate in the bloodstream (hemoparasites) were investigated using specific tests. The parasites included species of public health importance, e.g., the causative agents of leptospirosis and leishmaniasis, as well as others, such as the rabies virus that represents a threat to species conservation. On one hand, rice cultivation appears to favor the maintenance and abundance of ocelots, due to the abundance of small rodents in the fields. On the other hand, it appears that contact between parasites and hosts may be increased due to the rice fields – both for prey and predators, potentially increasing the rate of parasite transmission.

These factors may explain the poor health conditions observed for many of the captured animals, but further investigations are needed. For example, a relevant factor to consider is the use of agrochemicals, a common practice in many agricultural areas. These products can weaken immunity in exposed individuals, and therefore have the potential to negatively affect the health of animals in the study region. The risk is even greater for carnivores like the ocelot whose exposure increases indirectly through consumption of prey species that are also exposed to the agrochemicals (i.e., bioaccumulation). The Ocelot Project will continue to investigate wildlife health with a focus on assessing the effects of agrochemical exposure and prey species parasites. Field activities will also continue with annual monitoring of felines using GPS collars. Focused on populations of ocelots and small mammals, the GPS collar monitoring will provide more in-depth information on range use. Next steps for the Ocelot Project will depend not only on essential continued support from the partner ranch, but also on establishment of new partnerships that advance research efforts.

The project expects to increase knowledge about the investigated wildlife, providing important information that can be applied by public and private sector decision makers to improving management of production areas. The aim is to reconcile agricultural production goals with conservation of the Pantanal's precious biodiversity.

nivores evaluated showed positive, but low titer, serological test results for rabies. These results indicated exposure to the virus without clinical manifestations of rabies, since several of the sampled animals were recorded by camera traps more than 120 days after parasite collections (120 days being the maximum survival period for an animal with clinical manifestations of rabies).

With respect to *Leptospira* sp., both prevalence and titers were high, with about 70% of individuals positive. Important symptoms of leptospirosis are related to renal dysfunction, and eight of the seropositive animals showed altered values of urea and/or creatinine, indicating kidney function problems. These health issues deserve greater attention. Analyses should be expanded and refined with the aim of guiding possible initiatives that help maintain the health of humans, domestic animals and wildlife.

NATURAL PRODUCTS COMMERCIALIZED CONSCIENTIOUSLY

Photo: Wetlands International

Sustainable Business Development in the Pantanal values people, their knowledge and behavior

BY CYNTIA CAVALCANTE SANTOS, RAFAELA DANIELLI NICOLA, ÁUREA DA SILVA GARCIA AND JULIO FRANCISCO ALVES FERNANDES

Small-scale tourism favors low-impact activities

Sustainable businesses are reaching niche markets more and more, driven by a society that is increasingly attentive and willing to opt for consumption of sustainable products. Despite continual challenges, there are efforts being advanced by legal bodies that are having impacts through incorporation of adaptive planning and management into human (sustainable business) activities.

In addition to concerns about management of natural resources, discussions on sustainability should include a holistic view of society's problems. Beyond the tripod of environmental, economic and social factors, other complementary aspects to consider include: cultural, ecological, territorial and political (national and international) dimensions. In this manner, sustainable businesses will value people, their knowledge and behavior.

The Pantanal is the largest contiguous continental wetland on the planet and, on its own, still maintains large well-conserved areas and healthy ecological interactions, enabling the development of a variety of sustainable products and services. However, to create truly sustainable businesses and markets for the products and services, collective efforts are needed.

The presence of humans in the Pantanal – registered since the 16th century – includes several ethnic indigenous groups (Guaikuru, Kadiwéu, Aruak, Guarani, Guató, Meridional Kaiapó, Payaguá) among other non-indigenous people, such as riverine and quilombola communities. Throughout the history of occupation, all of these communities have contributed to the wealth of knowledge that exists about plants, animals and the natural flooding regime, as well as to knowledge about their own community dynamics, i.e., cultural diversity, behavior and traditions passed down over several generations. Although these communities also influence the Pantanal landscape, for the most part, they coexist harmoniously with the region's biodiversity.

Geographically, the Brazilian Pantanal encompasses 23 municipalities in two states: Mato Grosso (MT) and Mato Grosso do

Sul (MS). The principal economic activities include cattle ranching, fishing, tourism and mining. On the highlands that border the Pantanal floodplain, the predominant activity is ongoing expansion of large-scale cattle ranching and agricultural operations. However, small-scale economic activities are also gaining ground, mainly due to tourism, as is the case with the sale indigenous handicrafts and regional foods.

On rural properties of varying sizes, efforts are being made to organize and review current practices with the aim of finding alternatives that increase productivity while reducing impacts on natural environments. Focusing on cattle ranching, for example, producers are trying to optimize natural forage resources while taking environmental limits, biodiversity maintenance and Pantanal ecosystem resilience into consideration. The main objective is to increase the sustainability of production systems, either through monetization strategies, origin recognition or through the creation of eco-friendly (sustainability) labels that increase the profitability of a product or service.

With respect to local commerce, many fruits and seeds stand out, such as coconuts of the "bocaiuva", "buriti" and "acuri" palms. Some fruits, such as "guavira" and "jatobá", are commonly found at organic product fairs, even reaching niche markets in larger cities outside the region. Another product that is becoming more widely available is meat from the Pantanal caiman (*Caiman yacare*) that is marketed by two businesses with sustainable caiman harvesting systems in the municipalities of Corumbá (MS) and Cáceres (MT).

Commercializing honey from the Pantanal is also being considered as a means of diversifying production. It stands out as a sustainable activity due to the variety of species of wild plants that are visited by native bees and for being free from agrochemical contamination, as pesticide exposed crops are generally grown outside of the Pantanal. Since 2015 in the southern Pantanal, a certification has been used to differentiate locally produced honey: an indication of origin is provided by the National Institute for Industrial Property (INPI) based on regulations established by researchers, beekeepers and beekeeping associations.

Although very recent, projects using organic and sustainable alternatives are attempting to reconcile the maintenance of productivity with protection of natural environments. Most of the projects originate from partnerships between private initiatives and civil society organizations. These partnerships have developed out of a growing interest reflected in public policies and economic development programs that are facilitating the new arrangements. The consumption of products associated with these programs is linked to educational background and greater awareness on the part of consumers. However, to achieve success, these efforts will need to provide additional support for producers in order to create a steady demand for the products and set final costs (because comparisons between organic and conventional products have a strong influence on consumer decisions).

Product certification efforts encourage increased production and provide opportunities for producers to obtain eco-friendly (sustainability) product labels, which are important for guaranteeing access to niche markets. By developing product certifications for organic and sustainable production, new more efficient forms of using renewable natural resources will emerge, creating opportunities to improve sustainability across entire supply chains, e.g., during the phases that occur on Pantanal properties, such as adopting best practices for livestock management and ecotourism.

Due to the unique characteristics of the Pantanal, development of sustainable products and services will require a dynamic process of planning and promotion of best production practices, as well as ongoing monitoring and evaluation at each stage of the process. From environmental, economic and social points

ZONING

TERRITORIAL PLANNING ACCOMPLISHED!

Campo Grande has an unprecedented instrument for sustainable municipal management, combining socioeconomic potential and environmental relevance

BY FABIO MARTINS AYRES, ANA PAULA CAMILO PEREIRA, DANIEL MASSEN FRAINER, RAFAEL OLIVEIRA FONSECA, WALTER GUEDES DA SILVA, DANIELA VENTURATO GIORI AYRES, MARCOS ANTÔNIO MOURA CRISTALDO, CATIANA SABADIN ZAMARRENHO AND JUIANA DE MENDONÇA CASADE

Territorial planning and management are major challenges, both for decision makers and for local populations. The interaction between policy and management underlies planning, and with regard to land use and occupation, planning must respect the natural environment. But how do we reconcile varied – and sometimes contradictory – demands when carrying out territorial planning? And how do we connect territorial planning to actions carried out by public and private parties?

It is well known that sustainability requires three inseparable pillars: environmental protection, economic viability and social equity. Truly sustainable management in the public interest depends, therefore, on substantial democratic participation by the public and recognition of the value of multidisciplinary scientific knowledge. As such, the government needs to use appropriate instruments, so that sustainability becomes a reality and is integrated into people's daily lives. One of these instruments is Ecological-Economic Zoning, or ZEE (in Brazil).

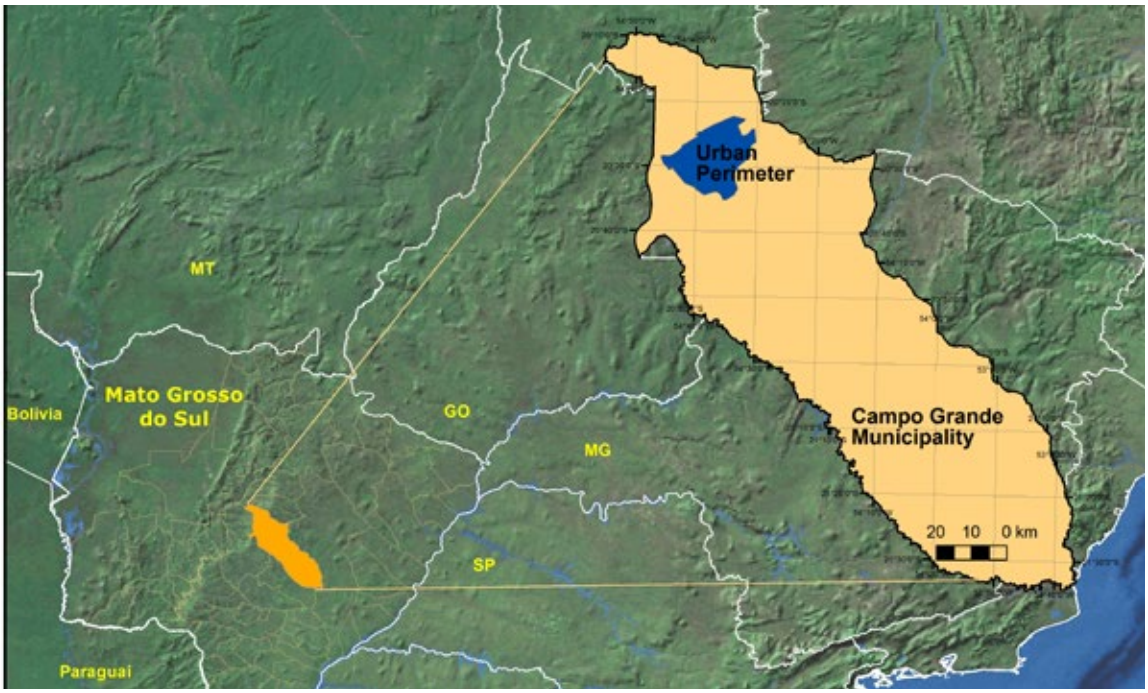
In Mato Grosso do Sul state (MS), the government began working on statewide zoning in 2007. As a foundation, the state adopted the ZEE matrix prepared for the Legal Amazon (the geographic area containing all nine states in the Amazon basin) by the Territory Management Laboratory at the Rio de Janeiro Federal University (LAGET / UFRJ). This model allows planners to establish a range of use conditions based on the relationships between socioeconomic potential and environmental vulnerability, resulting in defined homogeneous areas (zones) of Recovery, Expansion, Consolidation and Conservation. In this manner, it was possible to identify priorities for each zone and discuss how they can be addressed with zone managers and residents.

To develop ZEE/MS, 3 steps were needed. The first defined the objectives based on secondary data sources, feedback from society and technical-scientific knowledge. The main result was State Law 3.839/2009 that established the Territorial Management Program of the Mato Grosso do Sul State (PGT/MS) and approved the first phase of Ecological-Economic Zoning. The second step took place between 2010 and 2014 and focused on filling information and data gaps and refining ZEE/MS analyses.

Beginning in 2015, the third step began, this time at the municipal level, with development of zoning for the state capital, Campo Grande, using resources from the Inter-American Development Bank (IADB). This phase coincided with a second round of urban planning for the municipality, called the "Plano Director", carried out under the federal City Statute law (Federal Law 10.257/2001). During the planning process, instruments such as ZEE were used to develop environmental zoning for the entire municipality.

Campo Grande is a municipality located in the Cerrado biome at an average elevation of 600 meters. The region is located along a hydrologic divide between the Paraguay and Paraná river basins and has numerous headwater streams that contribute to both drainage basins, including some on the Paraguay side that form the Pantanal. Regional groundwater resources include the Guarani Aquifer. The total area of the municipality is 8,082 km^2, corresponding to 2.26% of the state's area, and the population in 2020 is 2.8 million people, as estimated by the Brazilian Institute of Geography and Statistics (IBGE).

The ecological-economic zoning of Campo Grande (ZEE/CG) is in full compliance with the three chapters of Federal Decree 4.297/2002: (1) for establishing environmental protection measures and standards aimed at ensuring environmental, water and soil quality and biodiversity



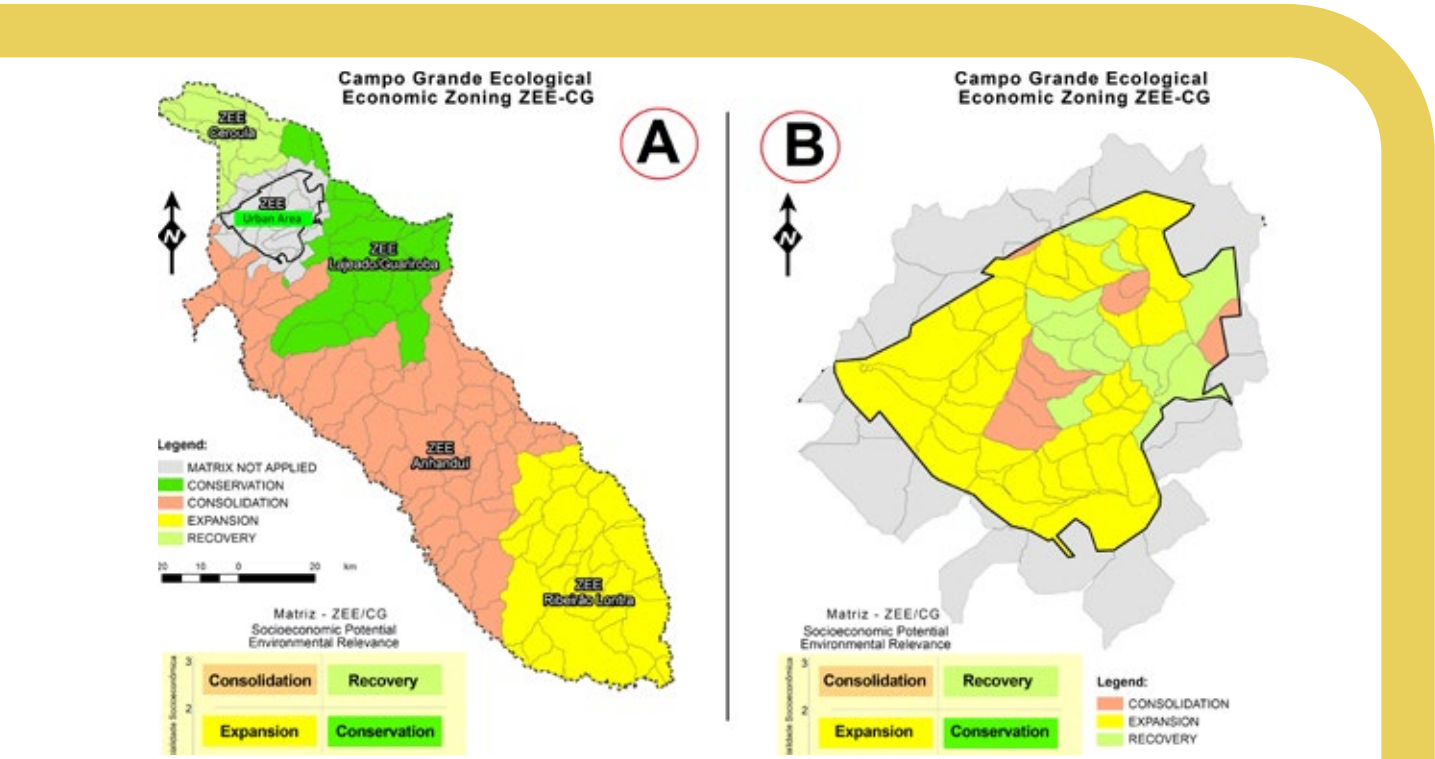
conservation, ensuring sustainable development and improving living conditions for the population, (2) for organizing and integrating decisions by public and private parties regarding plans, programs, projects and activities that, directly or indirectly, use natural resources, ensuring the maintenance of natural capital and environmental services provided by ecosystems and (3) for promoting ecological, economic and social sustainability with the aim of reconciling economic growth and protection of natural resources, favoring present and future generations and recognizing the intrinsic value of biodiversity and its components.

In an unprecedented way, ZEE/CG was implemented throughout the entire municipality, uniting zoning plans for rural and urban areas. Through this instrument, municipal administrators and public and private parties are now better able to understand and carry out territorial planning and organization in a balanced way, recognizing the municipality's socioeconomic potential and its environmental relevance.

The ecological-economic zoning of Campo Grande culminated with the enactment of a new Municipal Law 6.407/2020. It approves an analysis that defines 169 hydrographic basins and 58 micro-hydrographic basins as planning units. For each planning unit, the following were considered: the natural relief of the basin, available cartographic materials for delimiting areas, and the spatial configuration of urban and rural areas.

Two other important results from the law include: the creation of 5 zones, based on socioeconomic potential and environmental relevance, and the establishment of a territorial planning matrix. Thanks to exhaustive classification and analysis efforts, each zone has a detailed description and respective recommendations for use. The territorial planning matrix also contributes to the application of zoning.

Campo Grande has had an Environmental Licensing System (SILAM) since 1999 to monitor economic activities and businesses. In the new territorial planning matrix, construction



projects are grouped into 3 categories – according to their size and potential pollution impact – and designated for particular areas according to the newly defined zones: Ecological-Economic, Consolidation, Recovery, Expansion or Conservation.

The integration between territorial planning areas and activity or business categories allows planners to assign 4 types of use conditions: A (recommended), B (recommended, requiring management), C (recommended, requiring special management) and D (recommended, requiring specific management). For example, recommendation "A" is the least rigorous and only has environmental requirements already established by law. The use conditions of "B" and "C" are intermediary. At the other extreme, use conditions for "D" are the most rigorous, requiring specific terms of reference, in addition to consultations with the municipality.

The ZEE/CG also includes a territorial management guide with several general recommendations and specific suggestions for each of the defined zones. These materials are essential for supporting decision makers, ensuring a high level of technical-scientific discussion during the territorial planning process and guaranteeing participation by a well-informed general public.

Finally, Campo Grande municipal zoning also served as the basis for development of urban environmental planning, i.e., the "Plano Diretor de Desenvolvimento Urbano Ambiental" (Complementary Municipal Law 349/2019). The law regulates urban macrozoning, environmental zoning and identifies areas for urban expansion. Consequently, the municipality today has a legal framework that encompasses the entire territory, integrating environmental and urban demands. These instruments integrate municipal systems to serve managers and investors in an efficient, indiscriminant and accessible manner for everyone. And, they allow for effective citizen participation in territorial planning, respecting socioeconomic differences and recognizing the importance of environmental relevance.

THE BLEAK LEGACY OF FIRES

The main lesson from the catastrophic events of 2019 and 2020 is to take fire prevention seriously

BY LIANA JOHN, OSVALDO BARASSI GAJARDO, JÚLIA CORRÊA BOOCK, FLÁVIA ACCETTURI SZUKALA ARAUJO, PAULA HANNA AND BRENO MELO

Bureaucracy gets in the way of using preventive fire measures before peak dry season conditions in the Pantanal

Oxygen, fuel, ignition: fire does not exist without the combination of these three elements, and none of them were lacking in the Pantanal, punished for two years in a row by devastating fires in Brazil and neighboring Paraguay and Bolivia. Oxygen is always present in open-air environments. However, fuel and ignition sources can be controlled by taking preventive measures, beginning with monitoring of prolonged droughts and associated increases in fire hotspot numbers, as observed during 2018, 2019 and 2020. Historically, the Pantanal has undergone even longer periods of drought, such as the 14 consecutive years of unusually dry conditions between 1960 and 1974 when fires also devastated native vegetation and pastures. The Pantanal was able to recover from the fires, and past experiences were important for learning how to control wildfires over the next decades. But these lessons appear to have been overlooked for this 2020 decade.

The essential lesson that needs to be addressed is fuel: it needs to be reduced before the dry season. Management strategies to clear combustible vegetation include weeding, clearing or controlled burning. Prescribed burning or fire management can be efficient and cost-effec-

tive when it is controlled, fast and carried out during periods with cooler temperatures. Dry grass, hay, dead leaves, broken branches and fallen trees are fuels that can influence the rate of fire spread. This is common knowledge. However, a lack of clarity about the legal steps and procedures for fire management

Photo: Juliana Arini

combined with bureaucracy has constrained *Pantaneiros* (people from the Pantanal) from applying adequate fuel management techniques at appropriate times during the year, as they have learned over the years from experience and fire prevention specialists. These problems also impede newcomers to the region from learning adequate fire prevention techniques.

Ignition sources require continual monitoring. The Pantanal floodplain is regularly struck by lightning. The number of lightning discharges per year in Mato Grosso do Sul is 10/km2, well above the annual world average of 1 to 2/km2. Lightning is a natural ignition source for fires and must be monitored, so that fires are put out while they are still small. Human provoked ignitions are caused by cigarette butts, burning trash and/or accumulated garbage that is poorly discarded, fisherman campfires and poorly managed off-season agricultural fires. The control of fire ignitions depends on education and information and is the responsibility of everyone at all times.

Similar to the Pampas and Cerrado, the Pantanal is a fire-dependent ecosystem that evolved in the presence of periodic fires. The annual wet and dry seasons are well defined, and above average flood and drought periods have occurred for millennia. Living with devastating floods, or high fire risk periods, is engraved in *Pantaneiro* memories – residents of communities, ranches, indigenous lands or quilombolas (communities with descendants of Afro-Brazilian slaves). Traditional knowledge must be combined with scientific information, proven techniques and modern resources to prevent future catastrophes. Additionally, it is essential to avoid scenarios that cause environmentally harmful synergies between extreme climate events and inadequate land-use practices, including high impact land-use conversions, like constructing dams, draining wetlands and using unsustainable agricultural practices.

The prolonged drought and its impact on the natural flood pulse of the Pantanal was one of the main factors responsible for the increase in number of fires and the magnitude of burned areas in 2019 and 2020. Rainfall from the headwaters in the surrounding highlands is one of the main water sources that inundates the floodplain and feeds the rivers of the Upper Paraguay Basin (BAP). In 2019 and 2020, rainfall was 25% and 40% less than average,

respectively. These alterations influenced precipitation dynamics, causing rainfall to be concentrated over fewer days, reducing water absorption (water infiltration) time and consequently failing to replenish the Pantanal aquifer. As a result, the lowest water-level in 47 years was registered on the Paraguay River (similar to records from the 14-year drought in the 1960s / 1970s).

Unlike controlled fires, wildfires have a major impact on plants, wildlife and people's lives. The vegetation in flooded areas is rich in biomass, and organic matter accumulates in the soil, which is beneficial in terms of nutrient inputs and carbon sequestration. However, during prolonged dry seasons, this rich soil with organic material, similar to peat, facilitates the continued burning of underground fires even after the large visible flames have diminished. In slightly higher forested regions, there are many plant species that have developed fire resistant adaptations. For example, some have thick bark or roots capable of sprouting through the ashes. But there are also many fire-sensitive species. When fires are very large and create high temperatures, they can affect the composition and diversity of Pantanal flora, favoring resistant plants and reducing or eliminating sensitive ones. Maintaining the natural diversity and composition of plants is essential for the biome.

Among the animals, many species are able to escape or seek refuge in underground burrows, natural tree cavities or aquatic habitats. But, not all are quick enough to escape alive. Today, the Pantanal is monitored by a large number of researchers, equipped with cameras, radios and other devices to track and record wildlife in their natural environments. Even with these resources, the researchers were not able to estimate the total number of animals that were injured or died from the fires. The images captured while rescuing animals are devastating: tapirs and jaguars with paws burned to the bone; charred giant anteaters; contorted skeletons of large and small animals immobilized in running positions. In a drying pond, some surviving white-lipped peccaries were observed trying to protect their young among hungry caimans and the carcasses of other adults from the herd.

Many ranchers and local communities lost large portions of their lands that compromised their sources of food, work and income. What's more, the excessive smoke aggravated respiratory problems during an already critical period caused by the COVID-19 pandemic. Furthermore the fire destroyed medicinal plants frequently used to cure such illnesses. Tourism, already suffering due to the pandemic and the drought, was also severely impacted.

Photo: Osvaldo Gajardo

Fire brigades, trained and equipped (above), prevent large fires (right)

In Brazil, emergency brigades were set up to combat the fires, uniting volunteers from neighboring ranches, tourism inns, local communities and state and government agencies. Many volunteers relied only on improvised fire flappers (for smoth-

ering the flames) and courage. Sadly, some died surrounded by the flames. Others received protective firefighting gear, fire extinguishers, and other equipment donated from non-governmental organizations. For example, WWF-Brazil provided equipment for firefighters, firefighting training courses and donations of *food baskets* (containing Brazil's customary food staples) for local communities impacted by the fires and wildlife rescue teams working during post-fire periods.

Photo: Silas Ismael

WWF-Paraguay also facilitated firefighting training in 2019 and 2020 by offering technical support and partnering with local groups, the national government, and firefighters that came from Bolivia. In Paraguay, the focus was on the Rio Negro National Park, Los Tres Gigantes Biological Reserve and the San Rafael community. The community was hard-hit by the fires, which resulted in deaths and the loss of homes, vegetable gardens, and livestock corrals. In Bolivia's portion of the Pantanal, the number of fires was greater in 2019. In 2020, the number of fire hotspots was above average, but they were concentrated in the Chaco ecosystem. The two most affected wetland reserves were the Otuquis National Park and the San Matías Integrated Natural Management Area, both close to the Brazil-Bolivia border

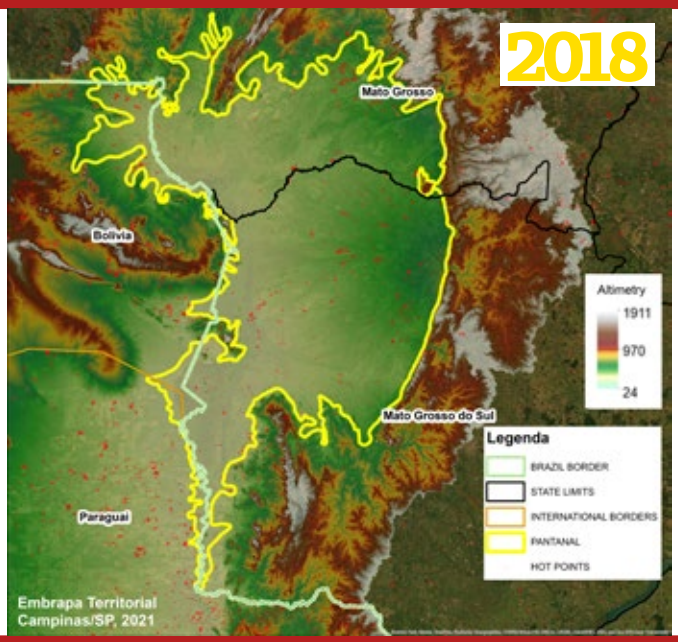
In the Brazilian Pantanal, where access via primitive roads and trails is difficult, fires are generally difficult to control. In addition, firefighting resources from the federal government arrived far too late. A lack of firebreaks was another factor that did not help slow down the fires. Firebreaks (*aceiros*) are strips of land that have been cleared of vegetation and are maintained all year round. They act as a barrier to slow or stop the progress of a fire, especially during the early stages. However, when the flames get very high and hot, they are able to jump gaps such as roads, rivers and firebreaks. In these situations, the best solution is aerial firefighting or heavy rains.

The lack of an efficient communication system in the Pantanal was also a problem. *Pantaneiros* organized themselves via amateur radio networks to provide information about wildfire movements. In the tri-national Rio Negro region, an international coordination network system was created between WWF-Paraguay and WWF-Bolivia offices. They circulated daily reports on wildfire movements and when necessary, set up emergency fire management groups.

To try to minimize the loss of wildlife from the fires, researchers, veterinarians and volunteers set up temporary frontline treatment centers in the Pantanal for injured animals. When necessary, animals were transported to a veterinary hospital / rescue and rehabilitation center (CRAS or CETAS) for further treatment. Some animals recovered and were reintroduced into their habitat. Others are still recovering. Numerous NGO campaigns helped raise money for medications, vehicles, food, capture equipment, animal

FIRE HOTSPOTS IN THE TRI-NATIONAL PANTANAL

Territorial distribution of total hotspots detected in the tri-national Pantanal by NASA's MODIS-Aqua reference orbital monitoring system during 2018, 2019 and 2020



enclosures and other important items that allowed volunteers and veterinarians to work in the field and treat as many animals as possible.

Dead animals, of all sizes, were scattered everywhere. At first, the abundance of carcasses provided some advantages for carnivores and scavengers. Over the months, however, a reduction in prey populations has become a problem. For herbivores - frugivores in particular - hunger arrived quickly, adding another threat for these animals so soon after the fires were extinguished. Because charred trees, leaves and fruits do not provide food, animals will need to find unburned areas of vegetation, possibly increasing competition between species. Researchers, landowners, NGOs, volunteers and tourism inn owners set up feeding station platforms and water sources for the surviving wildlife. However, in some locations, stations have attracted predators due to the concentration of potential prey, similar to a bait station set up by hunters. Therefore, the medium to long-term effects of providing food provisions for wildlife need to be carefully evaluated.

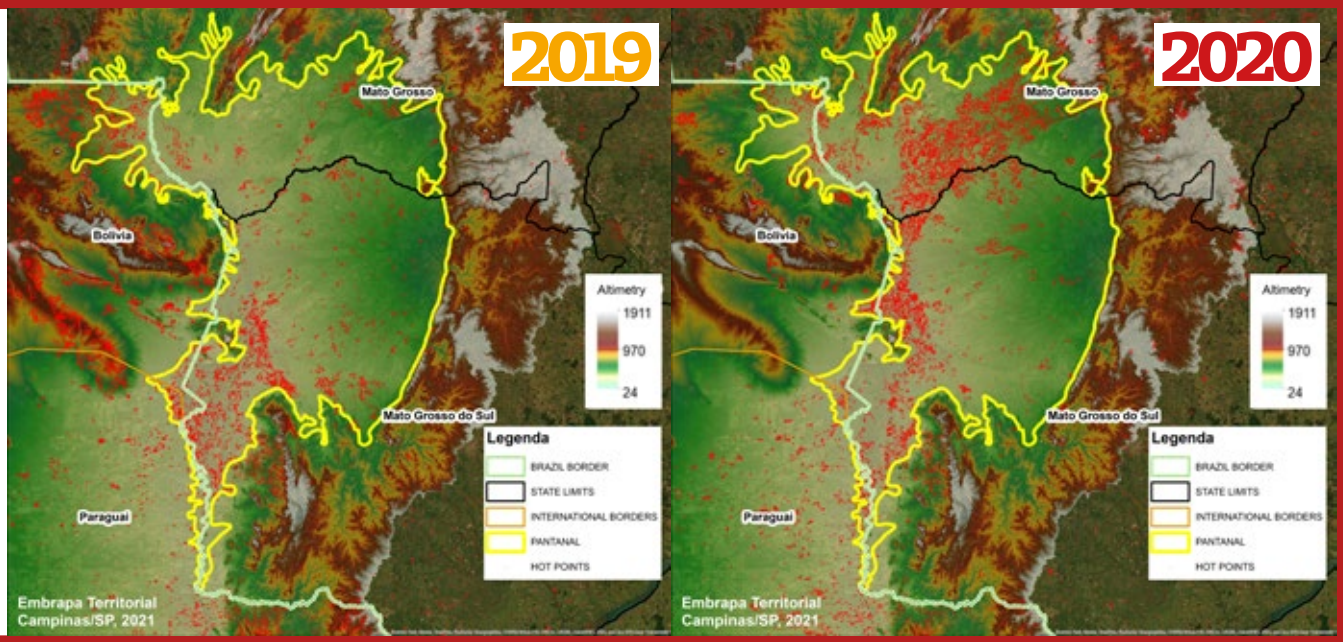
Rare, small and / or less charismatic creatures - such as microorganisms, insects, amphibians and reptiles - were equally impacted. Entire populations have been decimated. Although "invisible" to most people, they perform essential ecosystem services such as soil aeration / fertilization, decomposition of organic matter, pollination, etc. Their absence will have significant ecological impacts as the vegetation and wildlife populations slowly begin to recover.


snake carcass

Photo: Silas Ismael

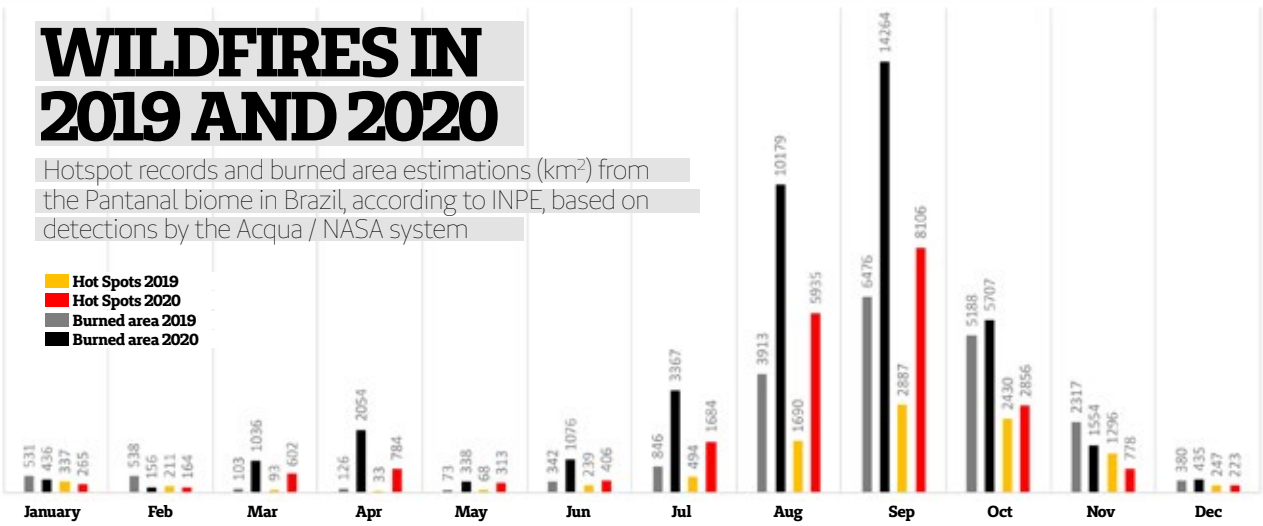

Greater rhea (*Rhea americana*)

Photo: Bruno Carvalho



WILDFIRES IN 2019 AND 2020

Hotspot records and burned area estimations (km²) from the Pantanal biome in Brazil, according to INPE, based on detections by the Acqua / NASA system



There are also concerns about water quality. With the arrival of the rains, after such intense and widespread fires, a large amount of ash is carried to lakes, *vazantes* (seasonal wetlands) and rivers. This alters the chemical composition of the waters. High concentrations of potassium and nitrogen compounds – beneficial for grass regrowth on land – can be toxic to a range of aquatic species, from insects to fish.

Fortunately, the Pantanal is resilient and is already rising from the ashes. The community's role now is to monitor and study impacts and changes from the fire and assist with restoration projects. One of the largest wetlands in the world, the biome is unique in terms of biodiversity and its capacity to support human – biodiversity coexistence. Best practices for land use – including maintenance of natural vegetation mosaics and use of fire prevention management measures – should be widely promoted, disseminated and incorporated into the daily routines of Pantanal inhabitants and visitors, the general public and government representatives. Prevention is always the best option, and it is an achievable goal for society.

STUBBORN SURVIVORS

With their nests threatened by fire, hyacinth macaws resist and do not abandon their chicks. Now they need your help!

BY NEIVA MARIA ROBALDO GUEDES, PEDRO SCHERER-NETO, FERNANDA MUSSI FONTOURA, LUCIANA PINHEIRO FERREIRA, KEFANY RAMALHO, ANA CECÍLIA DE PAULA LOURENÇO, BRUNO HENRIQUE GROLLI CARVALHO, MARCOS ROBERTO FERRAMOSCA AND THAMY DE ALMEIDA MOREIRA

During very dry years, when fires dominate the landscape and spread across the Pantanal floodplain, some wildlife are able to escape or find safe refuge. In most cases, fires reach high into the trees and spread quickly, and temperatures become excessively hot. Under these conditions, only those animals that can run, jump, crawl or fly fast enough in the right direction are able to escape.

This is what happened with many hyacinth macaws (*Anodorhynchus hyacinthinus*) in 2019 and 2020 when the Pantanal experienced severe drought and uncontrolled wildfires two years in a row. Since 1994, hyacinth macaw nests have been monitored by the Hyacinth Macaw Institute (HMI) at Caiman Ecological

Refuge (REC) in the Miranda River region of Mato Grosso do Sul state, Brazil. In September of 2019, a fire started on a neighboring ranch of the REC and spread quickly across the Aquidauna River, and throughout the region. A combination of factors was responsible for this fire: wind and low relative humidity, high temperatures and the accumulation of dry organic material. Unfortunately, the

Photos: Bruno Carvalho

flames reached the REC, one of the largest hyacinth macaw reproduction sites in the Pantanal.

At the REC, there are 98 registered nests, 51 of which are natural and 47 artificial. Similar to other macaws, they form monogamous pairs, and repeatedly use the same tree cavity (or artificial nest) for years. Palm fruits found near the nests are used to feed their young. Use of numerous macaw tree cavities is disputed by other birds, so the cavities make up an important component of biodiversity.

Hyacinth macaws are large birds and fast fliers, but when the fires arrived, they were in the peak of their reproductive period with eggs or newborn chicks. Frequently used nesting sites and an entire generation of hyacinth macaws was threatened.

The fire spread quickly and for 16 days all the ranch employees, hotel staff and researchers were fighting the out-of-control nightmare of a fire. After more than two weeks, the rains finally arrived and extinguished the flames.

About 60% of the REC burned with varying levels of fire intensity impacting different areas. For example, in some areas, all the vegetation was charred, and in others, only the grasses and undergrowth vegetation were burned. Extensive areas of acuri (*Attalea phalerata*) and bocaiúva (*Acrocomia aculeata*), important palm resources, were also destroyed. Both species occur in homogeneous formations, and serve as a "pantry" for hyacinth macaws, which have one of the most specialized diets of birds in the Pantanal.

Almost half (49%) of the active hyacinth macaw nests suffered some kind of impact. In some cases, the fire reached the nest site and both eggs and chicks were killed (this is called "direct failure"). Another type of impact, "indirect failure", occurred when the fire did not burn the tree, but offspring mortality was caused by heat and/or smoke. In some cases, the fire reached the nest, killing some chicks, but one survived ("direct interference"). In other cases the fire did not reach the nesting tree area, but there was surrounding environmental damage that reduced offspring survival ("indirect interference").

For some hyacinth macaw nests, tree trunks were lined with sheets of metallic straps to reduce the predation of eggs and chicks by other wildlife. When the fire spread across the landscape, these straps not only helped to protect the nests from the flames, but also protected the hyacinth offspring by deterring predators from climbing the trees.

Monitoring of fire impacts on the macaws began shortly after the fire and continued until the end of their reproduction cycle in 2019. In addition to monitoring nests, other factors related to burned vegetation and the survival of offspring were evaluated. For example, the loss of ripe palm resources, such as acuri and bocaiúva; the decrease in fruit production and the loss of monodominant palm formations, such as *acurizais* and *bocaiuvais*; and the increased rate of predation on adults and offspring. Monitoring data on fire impacts will be necessary for several years in order to determine the effects on plant and animal communities; this will include monitoring of hyacinth macaw disputes with insects and other birds that have also lost nesting sites and will try to occupy suitable nest cavities.

The hyacinth macaw reproduction center at REC is considered a natural laboratory for gaining knowledge about the complex relationships between the macaws and their environment. Ultimately, the effects of fire-related losses on current and future generations still need to be observed, especially if the offspring do not join the reproductive population within 9 or 10 years. All of these observations will contribute to discussions on fire prevention and remediation measures, focusing on reducing negative impacts during and after the fires.

In fact, some lessons learned in 2019 were applied to protecting hyacinth macaws during the 2020 breeding season when the Pantanal floodplain burned again. The fires were caused by a prolonged drought combined with strong winds and high temperatures, the accumulation of highly-combustible decomposing vegetation and weak enforcement measures for controlling unauthorized burning. In 2020, temperatures were higher and fires were more numerous, widespread and difficult to control. New areas were burned in 2020 such as the São Francisco do Perigara ranch in Mato Grosso state, an important refuge with the highest concentration of hyacinth macaws in the Pantanal.

Photo: Thamy Moreira

Metal straps and weeding protect nests (top and next page right). Acuri coconuts matured a year later (next page, left)

The Hyacinth Macaw Institute has been monitoring hyacinth macaw nests on the ranch since 2000 when the first population survey was conducted. In 2005, the team initiated an evaluation of the hyacinth macaw's reproductive success by registering and mapping the nest sites. On July 30, 2020, data indicated that when a fire reached the neighboring Perigara Indigenous Territory, home to the Boe people (formely called Bororo), it was raging and fierce. Help to put out the fire came from

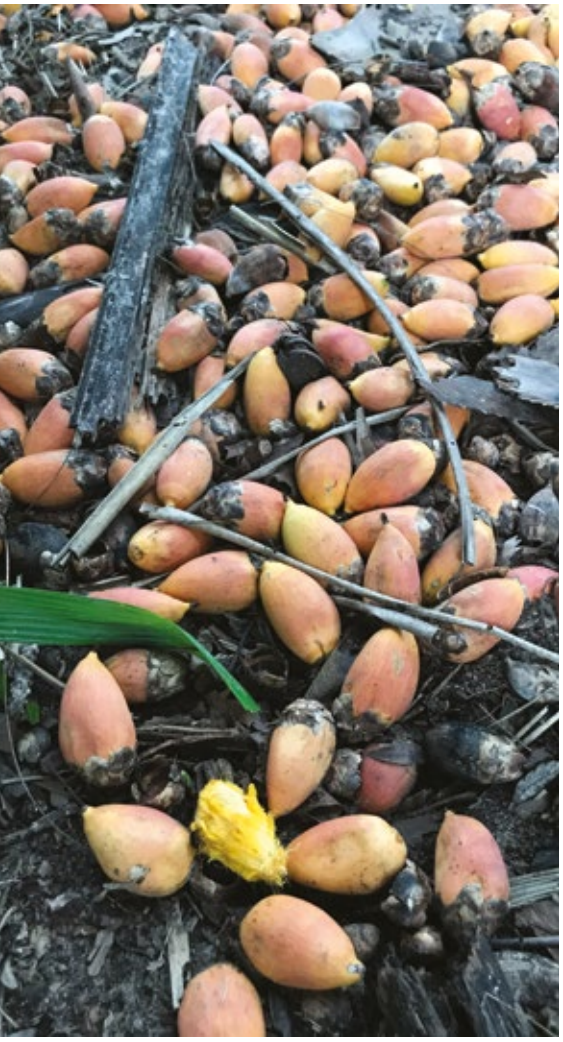


Photo: Neiva Guedes

Photo: Bruno Carvalho

neighboring farms, volunteers, and firefighters from the SESC Pantanal private reserve.

However, fires are difficult to control in a region with difficult access, without roads, with little water during the dry season and sparse infrastructure. Consequently, it didn't take long for the fire to reach the São Francisco do Perigara ranch, and by August 1st, small Cerrado forest patches started to burn. Unfortunately, the fire quickly spread throughout the property and burned for 21 days, causing varying levels of damage to 92% of the ranch. Only the area around the ranch home, where the macaws roosted and some other patches of vegetation escaped the fire.

The researchers were only able to assess the impacts on the hyacinth macaw population a month after the fire. Many carcasses had already decayed or been consumed by scavengers, so could not be counted. Even so, thousands of mammals, reptiles, amphibians and insects were lost along with important habitat and food sources burned in the fire. It is very difficult to obtain accurate numbers on animals and species impacted by the fire, but the loss was enormous.

In addition to the plants and animals, numerous ecological and functional relationships were destroyed or damaged. Tree cavities, nectar production, the abundance of fruits and many other resources - essential as dens and nesting sites or food resources – will take years or decades to recover.

About 35% of hyacinth

macaw nests at the Perigara ranch were affected by the fire. Fortunately, all of the active nests were in areas with moderate-intensity fires, often burning at the base of the tree, but without flames reaching the nesting cavity. Based on the age of fledglings, researchers concluded that they were born after the fire. Some nests were preserved thanks to the clearing of the vegetation (firebreak) around the trees in January 2020. This management strategy reduces the amount of fuel for the fire and the height of the flames.

Although many of the hyacinth macaw palm resources from *acurizais* and *bocaiuvais* were destroyed, the adults continued to remain on the ranch. A total of 736 adult hyacinths were registered after the fire, a number close to the 750 observed in August 2019. However, they stopped using their usual roosting site close to the ranch home, where they have been gathering for over 60 years. Small groups of macaws were found, scattered near small, drying ponds. A large group remained around a lake with abundant water and piles of *acuri* and *bocaiúva* nuts regurgitated by cattle. The macaws traditionally follow the cattle in the pasture and pick through the cattle regurgitations for palm nuts, because it is easier to crack open the nuts once they pass through a cows' digestive system.

Based on lessons learned about post-fire management, it was essential to immediately supplement reduced fruit availability with *acuri* and *bocaiúva* nuts provided at feeding station platforms. Additional water sources were also necessary, and by December 2020, two wells and twelve water troughs / dugouts were built for the hyacinth macaws. The trunks of all of the trees with active nests were lined with sheets of metallic straps. Artificial nests were replaced or reinstalled to replace damaged ones, and additional nests were placed throughout the region to compensate for the loss of fire damaged natural cavities.

Natural nests in trees need maintenance to increase the longevity of the tree cavity. This includes clearing combustible vegetation at the bases of the trees. Installing camera traps post-fire helps monitor the general behavior and movements of birds and wildlife. Monitoring the natural recovery of key plants such as *acuri, bocaiúva* and *manduvi* (*Sterculia apetala*), the latter which the hyacinth relies on almost exclusively for nesting, is also important. If the data indicates low post-fire regeneration of these key species, then planting of seedlings and seeds will be initiated to help restore these important resources.

Photo: Bruno Carvalho

Remarkably, parental care behavior was observed with camera traps during the fires. Videos of hyacinth macaws recorded how parents did not abandon their chicks or eggs, even when the fire was close. And now, like all the other fire survivors, they must overcome three main challenges: finding food and nest sites (protected from rain or direct sunlight), and they need to be in good condition in order to defend themselves against predators.

At Perigara, surviving macaws follow the cattle to eat regurgitated acuris

In the wake of the wildfires that advanced across large portions of the Pantanal, the demand for healthy habitats, nest sites, and food resources is much greater than what the environment is able to supply for wildlife. This may cause displacement and dispersal of individuals or species. For this reason, new projects - including management of the second macaw chick - should be discussed and developed in partnership with technicians and analysts from the Chico Mendes Institute for Biodiversity Conservation (ICMBio). Clarifying: although the hyacinth macaw lays two or sometimes 3 eggs per clutch, the pair is unable to feed all the fledglings. Only the strongest chick of each clutch survives to the age of flight and leaves the nest. Management of the second chick involves rescuing the weakest chick(s) from the nest and raising it for future reintroduction into the wild; artificially increasing the survival rate of the new generation.

Many lessons emerged from these two fire-impacted years. Nature will recover. Signs of recovery are seen a year and a half (January 2021) after the fire at REC. The rains have renewed the landscape. *Acurizais* produced ripe and green fruit bunches from *acuri* palms still black from the flames. Like the *acuris*, other Cerrado plant species have fire resistant traits and show resilience. However, large areas have been burned, many ecological functions have not been reestablished and due to the long recovery times, there will be food shortages for many animals, some of which are vulnerable species.

This is the case for the hyacinth macaw. Despite its size and demonstrated resistance, the species needs special attention and an Emergency Recovery Plan to minimize fire impacts over the short, medium and long-term. The support of society will be essential during this process.

NATURE'S NURSES

Pollinators help the Pantanal recuperate from devastating fires by distributing the pollen of a wide variety of plant species across the landscape

BY CAMILA SILVEIRA SOUZA, PIETRO K. MARUYAMA, CAROLINE L. GROSS AND ANDRÉA CARDOSO DE ARAUJO

Photo: Camila Souza

In 2020, the Pantanal biome faced one of the greatest droughts in its recent history and suffered uncontrolled wildfires. This all happened without fully recovering from the fires and drought of 2019. During this critical period, the Pantanal floodplain also suffered – and continues to suffer – from the effects of deforestation. All this devastation has impacted – and continues to impact – native animals and plants, including species

known to science and those we still have not discovered. Adding to the severity of these impacts is the disruption of plant-animal interactions. Most plants depend on their pollinators for fruit and seed production and to ensure their reproductive success.

For this reason, it is essential to recognize the importance of plant-pollinator interactions to ecological communities in the Pantanal. This is especially important for the current recuperation phase, during which appropriate conservation strategies and decision-making that ensure the survival and resilience of all plants and animals are needed. Just to remember, resilience, is the capacity of an ecosystem and/or population to respond to a disturbance by resisting environmental damage and recovering quickly.

Photo: Camila Souza

Bee visits the water primrose flower (left, previous page) and the bumblebee pollinates the yellow "paratudo" (left)

In the dry and burned Pantanal, where the slow healing process is in progress, observing plant-animal interactions in nature can be a rewarding experience. Sightings of frugivorous birds feeding on fruits or hummingbirds looking for nectar and pollinating flowers are special. These interactions are mutually beneficial: plants concentrate energy into the production of flowers and fruits, and in return, they attract animals. Animals move plant genes across the landscape and their service is rewarded with food.

Mutualistic interactions are widespread in nature and have played a major role in the diversification of life on Earth. A persistent challenge is to understand how these mutualistic interactions evolve, coevolve and vary between species and communities. Thus, in a community, although interactions between plants and pollinators occur between two species, they also form part of a network in which tens to hundreds of species interact directly or indirectly with each other. Gaining knowledge about the roles played by different species in this network is essential to understanding the structure and functioning of communities. To what extent are species interaction networks impacted by environmental changes such as deforestation, fires and global warming?

Interaction networks have distinct patterns in different communities. One of these patterns is the formation of subgroups of species that interact more with each other than with other species in the network. Such subgroups of species are called modules. They can be formed due to

different processes, for example, as a result of greater overlap between particular plant and pollinator species in time and space, or greater specialization of some pollinators for plants that have certain traits and floral resources. In addition, the availability of resources offered by flowers to their pollinators, such as the diversity of flower shapes, types of nectar/pollen/oil and color, can influence the structure and dynamics of these interactions.

Photo: Karen Santos

Stingless bee (*Trigona spinipes*) on herbal flower (*genus Richardia*)

In order to understand plant-pollinator interaction networks in the Pantanal, a study was carried out in three different vegetation mosaics of the Pantanal biome. The different vegetation mosaics included flooded areas with monodominant formations of paratudo (*Tabebuia aurea*) and canjiqueira (*Byrsonima cydoniifolia*) and riparian forest formations representative of the Miranda subregion in the southern Pantanal.

Diurnal plant-pollinator interactions of the three Pantanal communities were documented for two years (October 2014 to September 2016). The objective was to

evaluate how interaction networks were structured in these environments. For example, the occurrence of species modules and flower traits responsible for the organization of the modules were evaluated. Did the dry and wet seasons of the Pantanal affect the network structure and were seasonal differences due to the amount of available floral resources or the flower traits?

A total of 14,512 plant-pollinator interactions were observed that included 78 animal species and 105 plant species. Bees were responsible for 87% of all interactions; followed by birds (8.9%); other insects, such as flies and beetles (3%), and butterflies (1%). The exotic bee, *Apis mellifera,* was the most common pollinator (65% of all interactions in the community). The native bee (*Bombus morio*) was the next most common pollinator, 5.4%, followed by the hummingbird (*Hylocharis chrysura*) and another native bee (*Trigona spinipes*), 4.7% and 4.5%, respectively.

Among the plant species, a common regional herbaceous plant (*Richardia grandiflora*) was responsible for most of the interactions in the community (14%). Inga vera was responsible for 9.3% of the interactions followed by the water primrose, *Ludwigia elegans* (5.9%), and *Tabebuia aurea* (5.8%), the latter two species with similar interaction percentages.

When looking at network interactions formed in the Pantanal, it is possible to identify 11 different modules. Most animal species belonged to more than one pollinator group. However, some modules were strongly associated with specific groups, such as hummingbirds, beetles or bees that specialize in collecting floral oils. In addition, the plants in each module had similar characteristics, such as size of flower, color, and floral resources (nectar, pollen and/or oil).

The network structure varied considerably between the dry and wet seasons. In the dry season, the network was characterized by reduced abundance of floral resources, and consequently, it showed higher levels of specialization and modularity. These results were similar to those from other vegetation formations in neighboring biomes, such as the Chaco and Cerrado. Seasonal variation does seem to affect the availability of floral resources and the interactions between plants and pollinators.

These results prompted an evaluation of the possible impacts of wildfires on plant-animal interactions. As more specialized interactions tend to occur during the dry season, fire can have serious impacts on plant-pollinator relationships. Furthermore, more sensitive native species are especially at risk, enabling exotic and invasive species, such as the European bee (*Apis mellifera*), to spread. Even before the uncontrolled fires, the European bee was a dominant member of the bee-plant interaction network.

Among other important measures to promote recovery of Pantanal vegetation burned during the 2019 and 2020 droughts, it will be essential to preserve surrounding areas that were not burned. Only then will pollinators be able to return post-fire and actively promote pollen flow between flowers in the burned and unburned vegetation remnants. It will be essential to rely on the ecosystem services provided by these insects and birds to ensure the reproductive success of plant species and the reestablishment of plants and animals in burned areas.

LANDSCAPE PROJECTIONS

Landscape scenario simulations allow us to build a collectively desired future for the Pantanal

BY ANGÉLICA GUERRA, JÚLIO CÉSAR SAMPAIO DA SILVA, CÁSSIO BERNARDINO E FABIO DE OLIVEIRA ROQUE

Photo: Liana John

What future do we want for the Pantanal? This is a key question for planning a future built by all and moving forward in the right direction. When planning for the future, it is necessary to think about trends, desires, risks, uncertainties and consequences. Regional planning can only benefit from incorporating these ideas. Even though they are complex, probability analyses are able to simulate landscape change scenarios and produce results that can serve as a basis for public policies around the world.

This also applies to the Pantanal. In recent years, land-use simulation studies have revealed patterns of change highlighting both the potential benefits and possible impacts resulting from different pathways, or trajectories, in the future. In other words, based on these simulations, it becomes safer to move in a particular direction, because there are fewer unpredictable outcomes.

According to data presented by SOS Pantanal (a regional NGO), the Pantanal is the Brazilian biome with the highest percentage of native vegetation: approximately 87% remains on the floodplain. However, only 39% of the native vegetation remains in the highlands surrounding the Pantanal. According to a study by WWF, if the trend of vegetation loss from the past 10 years is maintained until 2050, approximately 6,000 km^2 and 8,000 km^2 of native vegetation will be lost on the Pantanal floodplain and in the surrounding highlands, respectively.

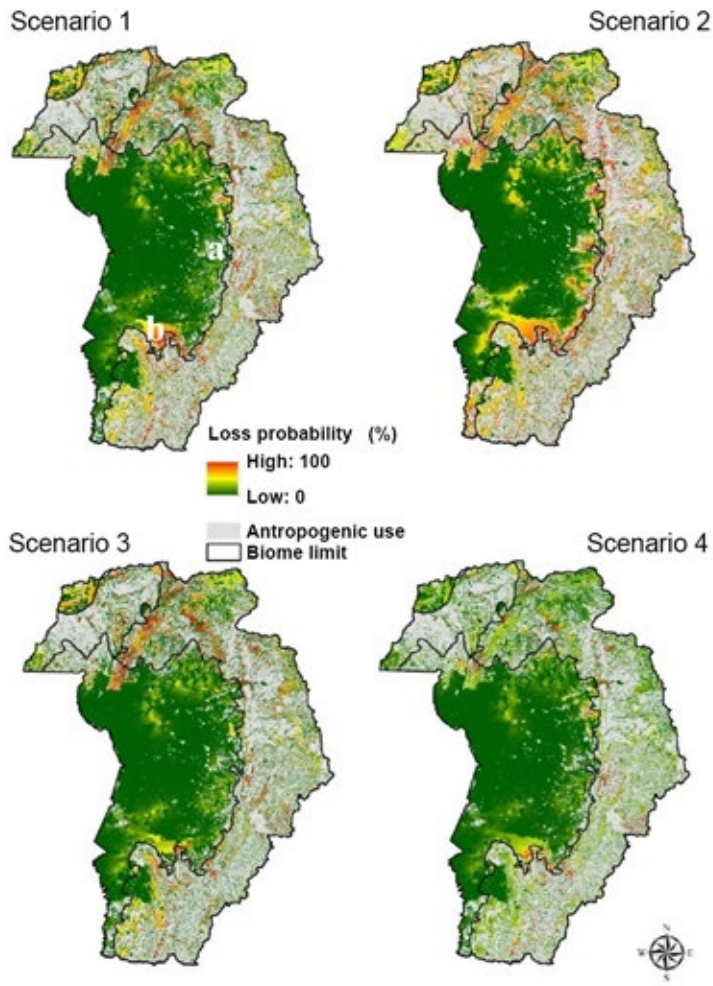
These projected values of vegetation loss may seem small when compared to other biomes, such as the Amazon, *Cerrado* and Atlantic Forest. However, it is important to point out that the 2050 projection of 6,000 km^2 of native vegetation loss in the Pantanal is concentrated in a small transitional area between the floodplain and highlands called the "Pantanal arc of native vegetation loss".

In two of the areas located in the "Arc", native vegetation is already limited to steep hillsides and slopes and Permanent Protected Areas (APPs). In another area of the "Arc", the river is not protected by a riparian APP as required by the Forest Code.

In the "Arc", the loss of vegetation occurs mainly through conversion of native habitat to planted pasture and crops. Landowners find this region ideal for native habitat conversion, because it does not experience the typical flood pulse of the Pantanal. A crucial observation is that the conversions are often concentrated in the same general region or in neighboring locations. It is also worth emphasizing that these vegetation loss values were projected for a scenario of full compliance with federal and state laws, as well as maintenance of current livestock production practices. If a significant increase in livestock production occurs, the losses will be greater and/or more concentrated. In addition, if we consider the possibility of strong growth in rural production - with expansion of crops or planted pasture and weakening of environmental laws - by 2050, native vegetation loss could reach 12,900 km^2 and 10,000 km^2, in the Pantanal floodplain and highlands, respectively. In reality, native habitat conversion in the "Arc" has occurred very rapidly, highlighting that the region requires urgent implementation of public policies that reduce native vegetation conversion.

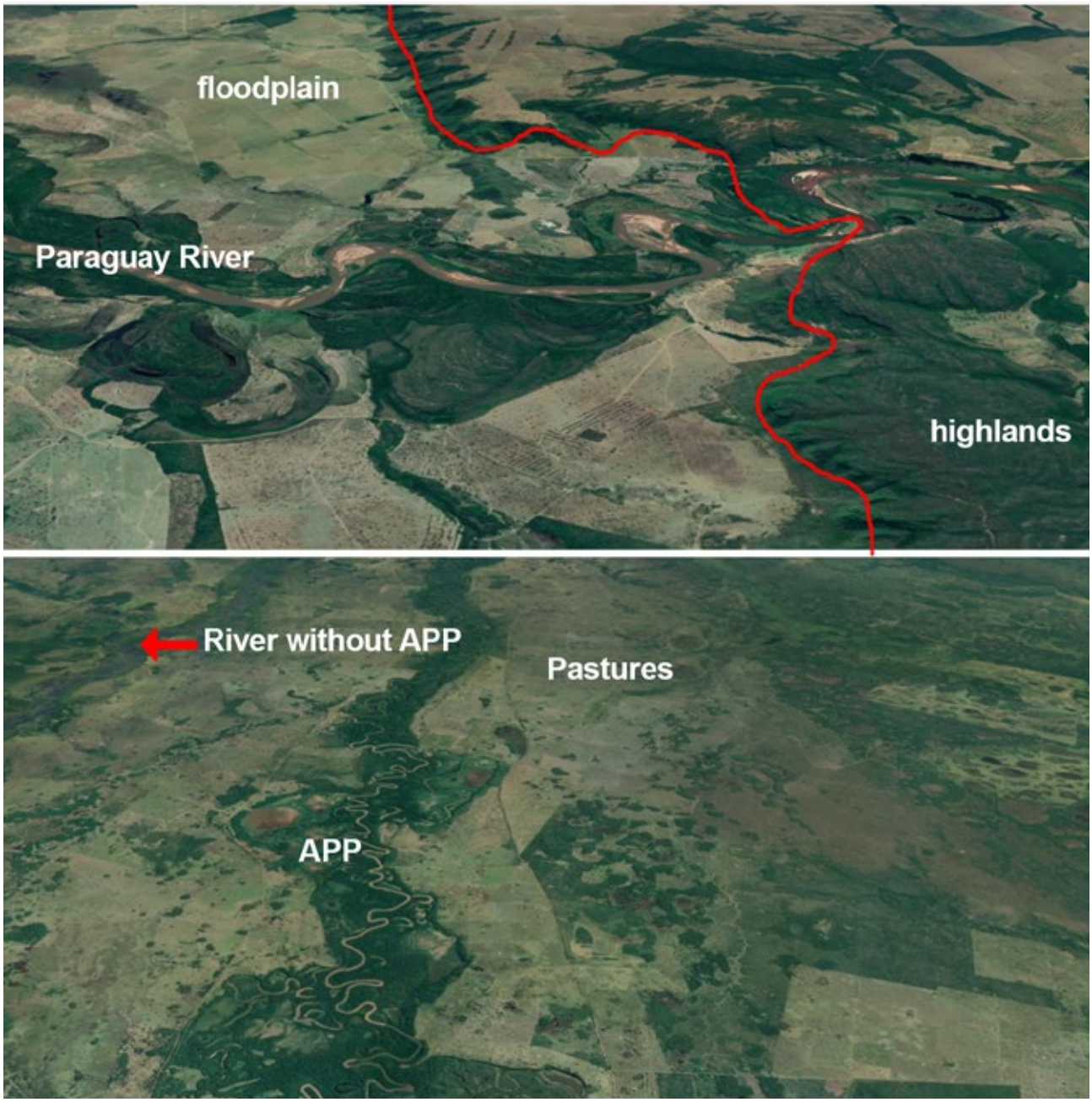
Fortunately, simulations don't indicate only negative

PANTANAL NATIVE VEGETATION LOSS SCENARIOS



scenarios. They also point out positive outcomes such as the value of biodiversity conservation associated with an increase in protected areas and compliance with environmental laws. Working toward favoring these positive scenarios, as alternatives to negative ones, is a very effective option for developing regional public policies. In addition to preventing native vegetation loss, ecosystem services associated with these areas, such as soil conservation, carbon stock maintenance and others, would be maintained.

Research on landscape scenarios is just beginning



in the region. However, results can already contribute to discussions concerning a desirable future for the Pantanal. Public policies based on clear and objective information favors smart and sustainable decisions. Furthermore, landscape scenarios can provide alternative pathways, or trajectories, that promote positive outcomes for biodiversity, and for the people living in the Pantanal or who are from the Pantanal. It is feasible to reconcile conservation of biodiversity and agricultural production, and reduce negative environmental consequences. After all, cattle ranching and crop farming in the Pantanal and surrounding highlands are directly dependent on the preservation of ecosystem services.

Watch a video illustrating land use changes in the "Pantanal's Arc of native vegetation loss". Available from the link: https://tinyurl.com/y28xpl6b.

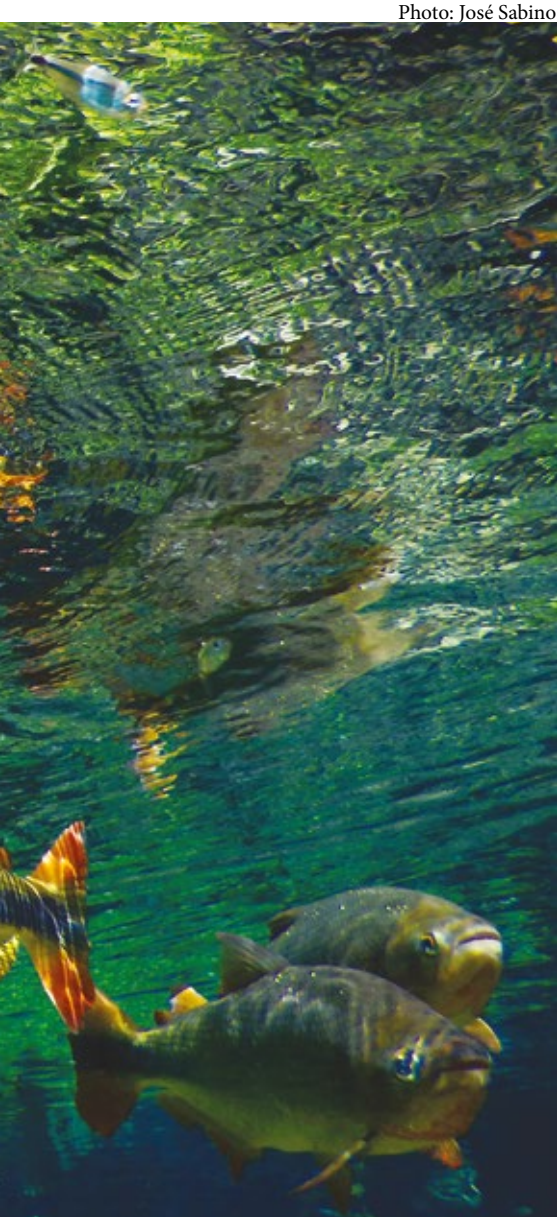
TOURISM AND CONSERVATION

FISHES OF BONITO

Project commemorates 20 years of connecting science, communities, species protection and sustainable visitation

BY JOSÉ SABINO AND LUCIANA PAES DE ANDRADE

Photo: José Sabino



Piraputangas wait for fruits dropped by Capuchin monkeys

Just after dawn, a gallery forest trail led two researchers and a guide to the banks of the Rio Formoso in Mato Grosso do Sul. It was July 1995 and the crystalline rivers of Serra da Bodoquena had piqued the interest of the two scholars. Local observations made by resident Paulo Ronda punctuated the conversation, drawing the attention of friends Otavio Froehlich and José Sabino to one detail or another that they observed through the observation window created by the remarkably transparent waters.

That day – and the richness of the exchange of information and impressions – left a mark on the visitors. It made such an impression that it changed the direction of the research conducted by José Sabino, then professor at the São Paulo Pontifical Catholic University (PUC-SP) and researcher associated with the Zoology Museum at the Campinas University (Unicamp). The fishes of Bonito rapidly became the object of his studies, fulfilling a dream and creating the project of a lifetime. One comment from the experienced guide, in particular, stood out from the lively chat by the river: "in Bonito, the capuchin monkeys (*Sapajus cay*) provide food for the 'piraputanga' fishes (*Brycon hilarii*)". Sabino immediately shared this with his doctoral advisor, biologist (and ethologist) Ivan Sazima. Ethology, just to remember, is the study of animal behavior.

A quick literature search confirmed records of "destructive foraging" by capuchin monkeys: for every two to three fruits placed in their mouth, many others fall to the ground. And, when the monkeys are foraging in gallery forests, fruits often fall in the river. When they fall into crystal clear water, fish are attracted to the abundant meal. So, a tip from a local observer culminated in a scientific description of a relationship between a nuclear animal (a monkey) that provides food to its followers (the fish), who take advantage of the monkey's leftovers.

Although the published scientific article was comprehensive, it resulted in some unexpected developments. The unusual connection between "piraputanga" fishes and capuchin monkeys in Bodoquena rivers captured the interest of people from outside academic circles. The results were summarized in Biology text books and included in articles for magazines like *National Geographic*. Teachers also discussed the subject matter with their students, and it was presented in several documentaries by international broadcasters, like BBC TV, *Animal Planet* and the *Discovery Channel*, as well as on programs for Brazilian television, such as "Globo Repórter" and "Terra da Gente".

The way in which this topic reached both scientists and documentary producers reveals the importance of the connection between local communities – in this case, represented by the tour guides – and researchers.

Photo: Olivier Lucanus

For scientific discoveries to have an impact beyond the restricted domain of academic production, it is necessary to listen with zeal and attention to reports from the local community, analyze the literature, adapt the knowledge with specialized language, publish a scientific article and, finally, share the knowledge gained with the local community.

Adopting these same steps, José Sabino located and described the albino suckermouth catfish (*Ancistrus formoso*), a naturally rare endangered species endemic to flooded cavities at the source of the Rio Formoso. This time, a tip about the existence of the catfish in caves came from the guide Sergio Gonzalez, the legendary "Sergião da Gruta".

For practically all animal groups, biodiversity is higher in Brazil than in any other country in the world. This is also true for the ichthyofauna: approximately 3,200 species of fish are known from our inland waters. This number will most likely continue to increase given the still limited knowledge we have about occurrences throughout the country. A significant portion of these inland fishes inhabit muddy or dark waters, making it difficult for people to observe them. So, the crystal clear waters of the Serra da Bodoquena region provide a great opportunity for observing and gaining knowledge about Brazil's aquatic biodiversity.

Studies in the region progressed from basic surveys of the fish fauna to more applied investigations on the ecology and conservation of particular species. Over the past 20 years, researchers based at the Anhanguera-Uniderp University created an extensive collaborative network comprised of specialists from Brazil and abroad. Publications contributed by this group have expanded our knowledge of biodiversity and promoted the conservation of this extraordinary natural heritage region. Naturally, this amazing window into the natural world is not only for scientists. Its unique habitats are ideal for humans to interact with freshwater organisms: the fish no longer considered just food or "smelly" animals, but admired as a tourist attraction!

Floating tours currently occur in the Prata and Sucuri rivers, in the Barra do Sucuri, Baía Bonita and Nascente Azul, the latter being an artificial environment. Among the approximately 200

Photo: Marcelo Krause

In Bonito's transparent waters, tourists snorkel in the Olho d'Agua spring (previous page) and watch large fishes, like the "dourado" (left)

thousand tourists received annually in the region, approximately 60% (120 thousand) opt for floating tours of the transparent waters, made with the support of guides, snorkeling equipment and neoprene clothing.

Floating tours in the springs and rivers of Bodoquena are a fascinating experience. There are few places in the world where genuine, harmonious contacts between visitors and animals are possible. Coexistence reigns. Respect and an absence of fear govern the connection between people and nature, regulated by the development of monitoring methods and sustainability indicators for this type of tourism.

The fishes are the stars. During a brief floating tour, it is possible to observe species of varying sizes, shapes and colors: from the imposing "dourado" (*Salminus brasiliensis*), one of the largest predatory fish in Brazilian rivers, to the small scarlet-red "mato-grosso" (*Hyphessobrycon eques*), to the grayish-blue "curimbatá" (*Prochilodus lineatus*) and even the unjustly feared "piranha" (*Serrasalmus maculatus*). In addition, the visitor sees a wide variety of aquatic plants, forming remarkable submerged gardens, which are inhabited or visited by crabs, snails, caiman, giant otters, tapirs and anacondas.

Another result of this experience is to perceive rivers differently, not just as places to obtain water or dump sewage. All of the "hidden" biodiversity is evident and starts to populate the minds of visitors, whether scientists or tourists. Regulations for visitors interacting with fauna have also changed: until the early 2000s in the Municipal Balneario (swimming area) of Bonito, tourists were allowed to feed the fish. This mainly attracted "piraputangas", always interested in potential food items thrown into the water. Pieces of bread, corn and processed snacks became part of the fish's diet, causing a significant increase of visceral fat and an average increase of 19% in the weight of examined specimens. At the request of the state's Public Ministry and the municipal government of Bonito, researchers from the Fishes of Bonito Project carried out a study that provided recommendations for regulating fish feeding. Today, tourists are only allowed to give limited quantities of nutritionally balanced fish feed.

In September 2004, in partnership with the University of São Paulo (USP), the Federal University of Mato Grosso do Sul (UFMS) and the *Smithsonian Institution*, members of the Fishes of Bonito Project carried out an extensive inventory of fish species from the Serra da Bodoquena region. The resulting list was

composed of almost 100 species, of which approximately 15% were previously not known to science, including some endemic species, such as the previously cited albino suckermouth catfish.

The Fishes of Bonito Project also produced results in the areas of education and environmental awareness. Through partnerships with floating tour organizers, such as those from the Recanto Ecológico Rio da Prata and Rio Sucuri, we produced educational booklets and underwater guides about fish species. The materials supplement the knowledge passed on by guides and promote greater understanding among visitors about the rivers and their inhabitants. In terms of scientific dissemination on a broader scale, results from the project inspired and continue to inspire the production of video documentaries.

Tourism based on biodiversity observation has become increasingly popular, especially because it is recognized as a solution for resolving conflicts around conserving or economically exploiting natural areas. Carried out following regulations for visitation limits established by scientific studies, it can work. In the case of Bonito, most tourism activities appear to have had positive impacts, since, over the past few decades, the integrity of ecosystems have not changed significantly as a result of visitations.

However, the beauty and scientific importance of the region are being threatened by factors other than controlled tourism. Since 2012, the increasing value of and demand for agricultural commodities has intensified land use change characterized by conversion of pastures and native vegetation to crop plantations. As a result, we are already noticing a disturbing trend: rivers where visibility reached 50 meters in the past currently may become cloudy from sediment runoff after rainfall events. Reports of these high turbidity events have been broadcast by the media, causing a great deal of worry and push back from the lucrative tourism industry responsible for 7 thousand jobs in Bonito alone and generating an annual income on the order of R$ 300 million.

The amazing water quality that characterizes the Serra da Bodoquena region – a paradise formed by scenic rivers, waterfalls and flooded caves – is at the mercy of impacts from land use change. It is not a question of demonizing one segment of society or another, but of imposing legislation that protects the Bonito region, especially

In order to preserve the crystal clear waters, tourism is controlled. However, agricultural activities continue impacting these sites

Photo: José Sabino

the Formoso and Prata rivers and all the associated biodiversity. The Crystalline Waters Act already exists (Law 1871/1998 MS) and requires that 150 meters of native vegetation cover is preserved on both sides of the rivers in the Serra da Bodoquena region. Without this protection, during heavy rains, the crystalline rivers turn muddy, setting off alarms among local residents and conservationists about the importance of protecting these unique environments.

The use of natural resources, whether for tourism or agriculture, can generate impacts that must be monitored, mitigated and addressed through planning, management techniques and environmental education actions. In this process, we aim to find integrated and consensual solutions for resource use that balance resource needs with mitigation of possible environmental impacts. Such a consensus is essential to prevent impacts and irreversible damage to sensitive and unique environments such as those in the Bonito region.

There is little point in creating visitation protocols for minimal impact or monitoring tourist activity if society is not involved and engaged in an integrated manner in protection of Serra da Bodoquena's aquatic ecosystems. Knowledge and qualified people exist. The most notable deficiency is the lack of political will to curb the actions of the agribusiness sector that is either not aware of, or not concerned about, the widespread damage and lasting impacts of their activities on natural systems. The disturbing attitudes of this retrograde portion of the "agro" sector, focused mainly on increasing profits, should give way to allowing multiple uses of the land and seek greater coexistence with other segments of society.

As a contribution and to provide continuity to the dissemination of knowledge generated over the past 20 years, the Fishes of Bonito Project has the genuine intension of making our network of specialists available to local communities in order to increase knowledge about regional biodiversity, encourage honest dialogues and resolve conflicts with the aim of conservation and sustainable use of Mato Grosso do Sul state's magnificent environments.

To find out more about the Fishes of Bonito Project, access the website: www.peixesdebonito.com.br

COLLABORATIVE RESEARCH

In addition to the coordinators at Anhanguera-Uniderp University (University for the State and the Pantanal Region Development), participating researchers in the Fishes of Bonito Project included biologists and specialists from the following universities: São Paulo (USP), Campinas (Unicamp), São Paulo State (Unesp), Brasília (UnB), Mato Grosso do Sul Federal (UFMS), Santa Catarina Federal (UFSC) and Pará Federal (UFPA), as well as collaborators from the *Smithsonian Institution*, *Georgia State University* (both in the USA), McGill University (Canada) and the Superior Institute for Applied Psychology (Portugal). Modern day science is not accomplished alone, but through collaborations. Advances are often more profound through teamwork. For this team, which included about 50 researchers, it is worth mentioning the significant number of theses and dissertations that were produced on the Serra da Bodoquena aquatic ecosystems, as well as the wonderful stories and narratives shared with local communities about the crystalline rivers and their valuable biodiversity.

Photo: Matheus Jeremias Frtunato

KEEPING AN EYE ON WILDLIFE

Wildlife must be monitored to ensure the health and conservation of species

BY HEITOR MIRAGLIA HERRERA, GRASIELA EDITH OLIVEIRA PORFÍRIO, WANESSA TEIXEIRA GOMES BARRETO E GABRIEL CARVALHO DE MACEDO

The concept of health - when referring to wildlife - must be discussed and understood as a system composed of elements and relationships capable of enabling the perpetuation of species, the maintenance of populations, and the coexistence of diverse communities in their ecosystems. However, the term health has a strong anthropocentric bias, influenced by the relationship between humans and their domesticated animals, whether for companionship or production. For this reason, it is common to arbitrarily define the well-being, disease and productivity of individuals and populations.

As is the case for humans and domestic animals, and even wildlife, individual health assessments are associated with clinical and laboratory tests. These individual assessments can be performed in the field through physical examination, identifying the presence of possible injuries, fractures, fur loss and measuring an animal's weight. In addition, physiological parameters such as body temperature, respiratory and heart rates, and capillary filling time help develop a more complete diagnosis. Additional sampling of biological materials for laboratory tests - whether hematological (blood), biochemical (metabolism), toxicological (toxic substances and poisons) and / or parasitological (mites, ticks, lice, worms, etc.) - contributes to a detailed assessment of animal health.

There are also indirect alternative

methods to evaluate wildlife health through population monitoring. Reproductive indexes over time, for example, are a powerful tool for the evaluation of wildlife populations.

Both field and laboratory analyses must be evaluated together. Care must be taken in clinical evaluations, because some parasitized animals may show non-specific symptoms or no clinical symptoms at all. Attention must be given to the interpretation of the laboratory results, because analyses can vary due to age, sex, physical and reproductive condition; environmental factors, such as the time of year and habitat quality; different capture techniques and the use of drugs for sedation and containment of wild animals. Furthermore, the levels of stress vary from one individual to another depending on the species, social structure, age and animal capture conditions (e.g., potential stress caused by trapping technique, handling, and proximity of humans). All of these factors must be considered when interpreting laboratory results.

It is worth mentioning that there is tremendous difficulty in conducting studies on wildlife in the Pantanal. Difficulties range from human and logistical resources associated with the lack of roads, communication, electricity and security, and with the challenging terrain for vehicles due to the Pantanal's environmental characteristics. As a result, only a small fraction of animals (sick or dead) with parasites are examined by specialists. Nevertheless, to date, 248 different parasites (such as arthropods, helminths, protozoa, bacteria, viruses and fungi) have been recorded from native mammals in the Pantanal biome.

Despite being considered as something negative, parasitism is an important promoter of biological diversity in wildlife populations. Parasites interfere in ecological processes as varied as competition, migration and speciation. They also influence their hosts' fertility and survival rates. In this sense, parasitism should not al-

Photo: Kamila Mechi

Photo: Carolina Garcia

ways be considered a harmful condition caused by organisms that survive at the expense of their host's health. It is also an ecological phenomenon linked to living things, and as such, must be discussed from an evolutionary point of view.

Of course, one cannot forget the parasites' ability to debilitate the physiological conditions of the host and alter the balance of various bodily functions and chemical processes. The severity of these changes depends on many factors: 1. some related to the parasite itself (amount of inoculum, different strains with different degrees of virulence and/or pathogenicity and co-infections); 2. others related to the host (age, sex, nutritional/immunological status, reproductive condition and race), and 3.some environmental factors (food scarcity, severe climatic conditions, forest fragmentation/reduction of the native habitat and global warming).

Photo: Carolina Garcia

Monitoring mammals in Nhecolândia: blood collection and physical examination of a coati (previous page top), collection of ocelot parasites (previous page bottom) and an ocelot with signs of scabies (above)

In the Pantanal basin, proximity and coexistence between wild and domestic animals make it difficult to identify the source of an infection: are domestic animals sources for wild animals? Or vice versa? In reality, this discussion is no longer relevant, as the modern approach treats the health of all organisms (species, people and their shared environment) as a unit (One Health approach).

The main exceptions are situations involving reintroductions of wild animals to natural environments. In these cases, each individual reintroduced back to their native habitat requires a health assessment. This is because while they were held in wildlife rehabilitation centers, they came into close proximity with other animals from different areas/regions. In addition to the stress of living in captivity, such contacts definitely increase the risk of infection by new parasites and/or the risk of multiplication of undetected parasites present in low numbers in animals with subclinical conditions (without signs and symptoms of the disease). Similarly the introduction of domestic animals, such as dogs and other pets from urban areas, or even cattle, brought from cities and other areas/regions of the country to Pantanal farms is concerning. These animals can introduce new parasites capable of infecting wild mammals.

In summary, wildlife health must be conceptualized in terms of the resilience and sustainability of populations. In this context, the scientific community must work together with civil society organizations in order to encourage the development and application of public policies that promote conservation. These actions will ensure the health of wildlife species, populations and communities, and guarantee continuity of ecological processes in the Pantanal.

LANDSCAPE MOSAIC

ENVIRONMENTAL GUARDIANS FROM SERRA DA BODOQUENA

The diverse ways that herbivorous mammals use the Pantanal and bordering highlands provide conservation tips for dealing with ongoing land-use changes.

BY CYNTIA CAVALCANTE SANTOS, FABIO DE OLIVEIRA ROQUE, PIERRE-CYRIL RENAULD E OLIVIER PAYS

Photo: M. Mamede

Of the almost 4000 species of terrestrial mammalian herbivores on the planet, only 74 species are classified as large herbivores, including the Brazilian tapir (*Tapirus terrestris*), the largest remaining native herbivorous mammal of the Neotropical region. As is the case for the tapir, more than half of these 74 species are listed as endangered, while the populations of the rest of the species are in decline. Some are iconic species, such as black rhinos (*Diceros bicornis*), common hippos (*Hippopotamus amphibius*) and African elephants (*Loxodonta africana*).

Photo: M. Mamede

White-lipped peccaries (left) and collared peccaries (next page bottom) are frugivores, while the brocket deer (next page top) is folivorous

On the South American continent, the large herbivores and browsers of the Pleistocene (Ice Age between 2.58 million and 11,700 years ago) went extinct approximately 5,000 years ago due to changes in climate, especially in relation to the rainfall regime. These extinctions also led to the disappearance of their predators, including in Brazil. Fossil evidence for this has been found in the Serra da Bodoquena, Mato Grosso do Sul, specifically in the Gruta do Lago Azul (cave of the blue lake), where paleontological studies confirmed the existence of the giant sloth (*Eremotherium laurillardi*) and the carnivorous saber-toothed tiger (*Smilodon populator*).

What is an herbivorous mammal? In general, it is an animal adapted (over many generations) to preferentially consuming plant material or parts (flowers, fruits, leaves, roots and even plant shoots). There are herbivorous mammals specialized in eating leaves (called folivores) such as the brazilian rabbit (*Sylvilagus brasiliensis*), the capybara (*Hydrochaerus hydrochaeris*), the marsh deer (*Blastocerus dichotomus*), and the brocket deer (*Ozotocerus bezoarticus*). However, the vast majority are fruit-eating herbivores (frugivores), such as opossums (genus *Didelphis, especially D. albiventris*), white-lipped and collared peccaries (*Tayassu pecari* and *Pecari tajacu*, respectively), pacas (*Cuniculus paca*), agoutis (*Dasyprocta azarae*) and tapirs. There are also herbivores called frugivore-granivores that mix seeds and grains with a diet of fruits, such as many small mammals, including the elegant rice rat (*Euryoryzomys nitidus*) and the white-bellied oecomys (*Oecomys bicolor*).

Ecologically speaking, herbivores participate in several ecological and biological processes and impact the ecosystem in numerous ways. For example, they are important seed dispersers. Their habit of turning over plant materials and soil while looking for food creates and physically modifies habitat structure. Furthermore,

Photo: M. Mamede

Photo: Jeffrey Himmelstein

they can influence vegetation formations explored by groups of different species that use the same food resources in similar ways (trophic guild structure).

The Serra da Bodoquena, located in the highlands of the Upper Paraguay River Basin, has historically been and currently remains a paradise for herbivorous mammals! Over many, many years, the variety of habitats with their diversity of vegetation has supported numerous species, many originating in adjacent biomes, such as the Amazon, Atlantic Forest, Cerrado, and Chaco. Many of these species have adapted to the vegetation types (savanna) that predominate in the region.

The Serra da Bodoquena is comprised of a variety of landscape types that include areas of agriculture and/or livestock production, and they vary widely in the amount of remaining native vegetation cover. By evaluating the response of herbivorous mammals to this range of scenarios, full of environmental gradients, it is possible to gain an understanding about how different species occupying the region use available habitats. There are at least 23 species of small, medium and large herbivorous mammals living in the region,

Photo: M. Mamede

The presence of marsh deer indicates a healthy landscape

all responding in unique ways to the percentage of forest cover remaining in the landscape.

This is because these animals have different behaviors and requirements that determine their use of habitats. For example, there are species more dependent on native vegetation, such as the white-lipped peccary, and the red and gray brocket deer (*Mazama americana* and *Mazama gouazoubira*, respectively). Although they also use open areas, these species spend most of their time in areas with a higher percentage of forest cover. This response is possibly associated with their diet that is dependent on native fruits and herbaceous plants. Other species have adapted better to open areas, mainly because they have a leaf-based diet. This is the case for the capybara, capable of surviving both in native grasslands and in planted pastures.

Explaining the different environmental responses of herbivorous mammals requires knowledge about their specific food and habitat preferences and their interactions with the landscape, people and other species. This knowledge is essential for designing dif-

ferent strategies and complimentary species conservation plans for herbivorous mammals inhabiting the Serra da Bodoquena. Aspects, such as landscape scale, and factors, such as land-use configuration (e.g., number and arrangement of landscape elements) and composition (e.g., percentage of native vegetation cover or agricultural and urban areas), should be considered.

Reconciling the often conflicting requirements for conservation and agricultural production is the greatest challenge for land-use management of the Cerrado and Pantanal biomes. Mato Grosso do Sul is one of the Brazilian states where more than 50% of its native Cerrado vegetation has been converted for agriculture and other land uses. Considering predictions for agricultural expansion in coming years, the Serra da Bodoquena region should be prioritized for long-term environmental planning that guarantees the resilience of the ecological system, its biodiversity and ecosystem services. The challenge is to implement conservation strategies that maximize biodiversity through agricultural practices requiring minimal deforestation and promoting restoration of degraded areas. In other words, articulate conservation and restoration actions with sustainable agricultural best practices. In the absence of natural habitat, herbivorous mammals will use marginal habitats. For this reason, it is essential to maintain a landscape mosaic and focus on solutions that favor conservation of forest fragments and corridors. This will prevent potential human-wildlife conflicts when, for example, species like peccaries consume corn crops. This will also guarantee the persistence of forest connectivity for wildlife in an environment where fragmentation of native habitats is increasing.

PHYSIOGRAPHIC REGIONS OF UPPER PARAGUAY BASIN

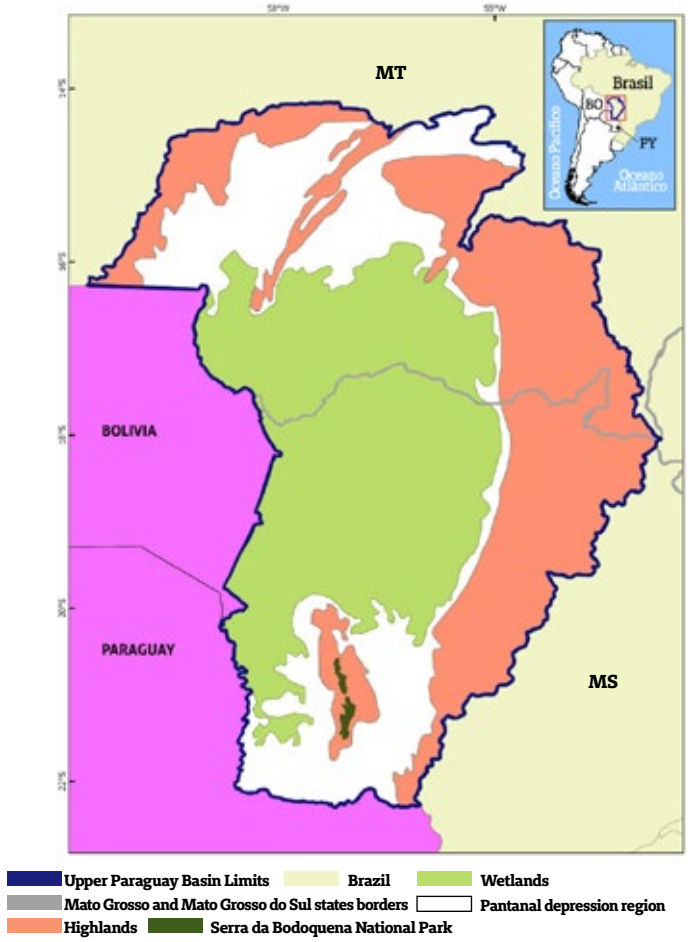


Photo: Gabriel Oliveira de Freitas

A HAPPY ENCOUNTER

A small bird endemic to the Chaco is spotted almost 80 years after its last collection

BY GABRIEL OLIVEIRA DE FREITAS, ALESSANDRO PACHECO NUNES E WALFRIDO MORAES TOMAS

A small migratory bird has gone unseen in Brazil for decades. Roughly 80 years! While researchers were monitoring wildlife in the field, a female suddenly appeared in front of their cameras in Corumbá, Mato Grosso do Sul (MS).

This rare flycatcher has two gray /white wing-bars and is commonly known as the cinereous tyrant (*Knipolegus striaticeps*). The male is indeed cinereous, primarily ash-gray in color with a red iris, and the female is brown with a rufous crown. This species is considered endemic to the Chaco region, and found in subtropical or tropical dry shrublands – at lower elevations within the range of 175 to 750 meters - in Paraguay, Bolivia and Argentina. In other words, it inhabits ecosystems similar to the Pantanal in neighboring countries, but only flies to Brazil for the winter, along with other migratory birds.

The cinereous tyrant was first recorded in Brazilian territory, around Corumbá, 161 years ago (1859) when a single male specimen was collected by members of the National Museum of Natural History, USA. It took eight decades (until April 1944), for researchers from the Museum of Zoology at the University of São Paulo (MZ / USP) to collect a few more specimens. Seventy-six years later, a photographic record of the species was captured in May 2020. The new photos and record of the cinereous tyrant became known to other bird watchers, and soon

new observations were documented further south in MS state (Miranda and Bonito municipalities) and at the Foz do Iguaçu (state of Paraná).

The Corumbá region is comprised of a diverse gradient of landscapes influenced by different ecoregions in Brazil and neighboring countries. Environments range from rivers, wetlands and lakes to mountains over 1,000 meters high. These landscape characteristics make this region rich in plant and animal diversity, and habitats. It is an ideal place for contemplating nature, including birdwatching, one of the fastest growing hobbies and a significant tourism attraction worldwide.

Today Corumbá is a popular destination for birdwatchers. Many species that are difficult to observe in other parts of the country, or are sighted only rarely in Brazil, can easily be spotted in Corumbá. And, sightings of large numbers of these species are possible.

Even though Mato Grosso do Sul has a diversity of fauna, some species are only found in Corumbá and along the western border with Bolivia and Paraguay. This is the case for the green-cheeked parakeet (*Pyrrhura molinae*); bolivian slaty antshrike (*Thamnophilus sticturus*); the white-shouldered fire eye (*Pyriglena leuconota*), and the blue finch (*Porphyrospiza caerulescens*). This also includes the newly described collared crescent chest (*Melanopareia bitorquata*) that only occurs in the Amolar Mountain Range (Serra do Amolar) near the Bolivian border in Mato Grosso do Sul.

Photo: Gabriel Oliveira de Freitas

The discreet cinereous tyrant male is almost invisible in the middle of the vegetation

In the Corumbá region, there are over 400 bird species, accounting for 66% of the Pantanal's birdlife and 61% of the species occurring in Mato Grosso do Sul. With such high diversity, the region is an important hotspot for birdwatching in Brazil.

More than 30% of the Pantanal has been destroyed.

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