



PANTANAL



**MACAWS SURVIVE FIRES
AND PROVIDE HOPE FOR
RESILIENCE** PG 36



EDIBLE
PLANTS
SUSTAIN
WILDLIFE AND
PEOPLE

PG 08



PANTANEIRO
HORSE IS
HEARTY,
TOUGH AND
EFFICIENT

PG 12



OCELOT
INFLUENCES
PREY AND
SMALLER
FELINES

PG 16



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 certain trees flowering and fruiting, 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 moderate intensity fires, 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 climatic extremes ranges 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 ravaged 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 three countries borders.

This Pantanal Science magazine edition presents some of the first fire impacts assessments and the long-term consequences that will affect the Pantanal over the coming years. There is also an

encouraging resilience report, as in the case of hyacinth macaws, whose nests were impacted by fire during their reproductive season peak 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 surviving hyacinth macaws' new generation.

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

region and present the Bonito Fishes Project 20-year commemoration, connecting science, communities and tourism. More than ever, this is a time to value traditional customs and knowledge – such as the *Pantaneiro* horses' services for handling cattle, and the edible native plants uses 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 natural resources protection, 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-Brazil reiterates its commitment to the vast biodiversity in the Pantanal and the surrounding highlands conservation. And their belief in solidarity without borders. Together we can face the challenges and prioritize environmental actions that guarantee the Pantanal ecosystem resilience!

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wild rice

Photo: Geraldo Alves Damasceno

ETHNOBOTANY

THE KNOWLEDGE AND FLAVOR OF NATURAL BIOCULTURAL ORCHARDS

Edible native plants enrich the Pantanal residents and visitors diet and valuing traditional knowledge contributes to species preservation 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 South America central portion stands out because of its rich cultural heritage that extends beyond four countries international boundaries: 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 Pantanal limits 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 scholars' attention was concentrated mainly on records of wild food plants included in the indigenous populations diets. However, since the 1990s, studies have expanded to include non-indigenous communities

Photo: Cynthia Santos



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

A preliminary list for the entire Mato Grosso do Sul State, in Brazil, developed by a researchers team from the Mato Grosso do Sul Federal University (UFMS) estimated that there are 294 native plants species 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), form-

ing true natural "orchards" with fruits, nuts, hearts of palm and other edible parts. Such occurrences contribute to the local human populations' cultures: they are biocultural orchards.

Some ethnobotanical main studies carried out in communities located along the Paraguay River during the last two decades resulted in 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 the communities adult residents, accompanied by botanical collections in the Corumbá and Porto Murtinho municipalities, 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 Paraguay River banks.

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 artisanal fermented beverages similar to beer.

Among the most important



“Laranjinha-de-pacu” (above), “bocaiúva” flour (right) and “carandá” (side page) enrich the *pantaneiros* and visitors’ diet



native food plants species, palm trees predominate: “bocaiúva” (*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 extractivism practices and

consumption of these wild food plants, passing down knowledge about them orally from generation to generation.

However, despite some plant species have local importance, traditional knowledge about them is in an eroding process, or has been lost already. 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 to obtain 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 wild plant species use. 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 Paraguayan River.

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

There are also still communities with a knowledge wealth 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 to value food plants; encourage the conservation and sustainable use of wild plant species and stimulate the income generation to improve the life quality in the communities, several actions were proposed and developed within the “Programa Sabores” (Flavors Program) scope.

“Programa Sabores” is a UFMS community extension program whose objective is to value 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. To incentivize consumption and commercialization, workshops are offered on good hygiene practices, harvesting and post-harvesting techniques, guidance on the fruits nutritional value and others. Program activities have extended beyond the commu-



Photo: Rosa Helena da Silva

nities where the research was carried out and have included 14 municipalities in the Cerrado/Pantanal region during the period from 2006 to 2020.

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 products kit 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 these extension program actions support, traditional communities residents already produce and sell 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 Pantaneiros ability to rescue neglected practices and knowledge that still exists within their communities has advanced the specialized edible plants use 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 wild food species conservation and the traditional knowledge maintenance are fundamental to sovereignty and the food and Pantanal communities’ nutritional security. 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 flood and dry seasons peaks, or during 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 *Pantaneiro* Horse

Breeders Association (ABCCP) was created in Poconé, Mato Grosso with the fundamental aims to promote, select and improve the breed.

Valuable genetic traits acquired during the natural selection long process gave the *Pantaneiro* horse the exceptional characteristics, such as 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 necessary to ensure the genet-



ic stability and breed diversity 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 transportation means for local populations (especially during flood periods) and is seen as a local culture symbol to the Pantanal visitors. 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 several 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 the animals' daily care. The breed inclusion in sporting events encourages family participation – especial-



Photo: Sandra Santos

ly by young adults and children – and it helps guarantee continuity, promoting the the breed conservation for future generations. To reinforce the *Pantaneiro* horse functional value 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 native pastures growth does not require fossil fuel inputs. This extraordinary breed animals 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 *Pantaneiro* horse functional work, 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 service performance.

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

sections 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 food sources for the animals (a provisioning ecosystem services example). The only external supplies and services needed for the study consisted of vaccines, medications, tools, fencing and labor. The service provided (handling cattle) could

Photo: Sandra Santos



between renewable energy and total energy, which provides an estimate of the service sustainability. In this case study, renewability was 64%. In other words, for the semi-extensive production system evaluat-

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

native pasture, or other supplies and services.

Another index estimated was the service quantification, 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 function-

Photo: Sandra Santos



have internal (management unit/farm) or external (commercialization) output flows.

Based on the energy inputs and outputs analysis from the study area, it was possible to estimate several energetic indices. One is the renewability index, that is, the relationship

ed, the horses primarily used natural resources, transforming native forage species into a functional service (handling cattle). Of course, renewability depends on the production system used to maintain the horses and will be affected by factors like the proportional use of

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

OCELOT, BIG OCELOT, WILDCAT OR LITTLE JAGUAR?

Discover the “spotted cat” most common species in the Pantanal and its strong influence on prey and smaller felines

BY HENRIQUE VILLAS BOAS CONCONE, ANDRESSA ROCHA FRAGA, ÉRICA FERNANDA G. GOMES DE SÁ, THIAGO ANDRÉ ALBUQUERQUE SILVA, LAÍZA DE QUEIROZ VIANA BRAGA, FABIANA LOPES ROCHA, KATIA MARIA PASCHOALETTO MICCHI DE BARROS FERRAZ AND PEDRO CORDEIRO ESTRELA

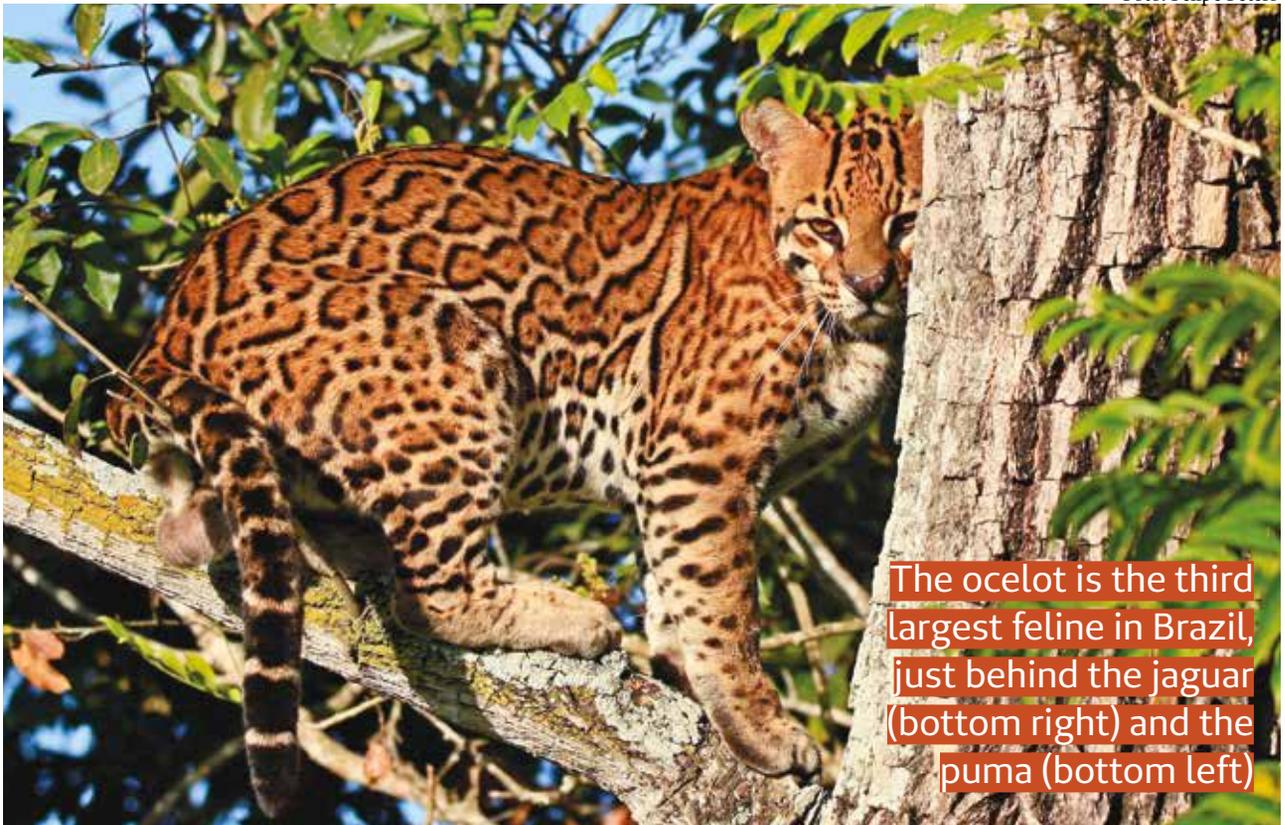
Wild animals' common names tend to be different regionally within a country, and even locally within a region. The most obvious exception is for “spotted” cats. Even though there are six distinct species in Brazil, they are often given the same generic common names throughout the country. It doesn't matter if you're talking about the smallest species – the oncilla or “small-wildcat” – 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, wildcat or little jaguar, generalizations that generate confusion when identifying the species, especially during local residents' interviews for preliminary assessments on these animals' occurrence in particular ecosystems.

These names use, 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 little jaguar. If it is a bit smaller, it is called ocelot.

And wildcat or forest cat is used for any feline 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 the puma (*Puma concolor*). An adult individual can measure between 1 to 1.4 meters in length from the snout tip to the tail tip, while its weight can vary from 8



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



Foto: Adriano Gambarini



Foto: Edir Alves

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.

The ocelot is widely distributed in Brazil and in the Pantanal. It is one of the most commonly sighted feline spe-

cies 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 agou-

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

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 seems to be much more related to the prey availability, rather than to the larger felines presence. In contrast, the impact of ocelots on smaller feline species is quite evi-



Foto: Felipe Peters



Foto: Felipe Peters

dent: 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 cats (*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.

All of the smaller “spotted” cat species preferentially inhabit forests and are active at night, so they come under the “*pardalis* effect” influence. 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 funda-

Foto: Adriano Gambarini



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

mental role in terrestrial ecosystems that make up the environments mosaic in the Pantanal: including wetland margins, forests and savannahs. Its presence is vital for maintaining the ecological processes dynamics through its interactions with a huge diversity of prey, larger predators and a range of competitors.

The ocelot conservation status 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 ocelot conservation status is also better in the Pantanal. For long-term conservation purposes, ocelot populations will depend on the remaining forests fragments maintenance in the bordering Cerrado highlands and especially on riparian corridors that



Foto: Felipe Peters



Foto: Felipe Peters

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 Pantanal region, the site was chosen for launching the Ocelot Project. Initially, studies focused on the diet and local occurrence of the species. These studies lasted two years (2002 to 2004) and contributed to a Master's degree awarded by the Mato Grosso do Sul Federal University (UFMS). A surprising result from the study was the numerous ocelot individuals sightings 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 rodents

source 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 local guides team 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 humans presence? If the ocelots density is high in the

landscape agricultural portions, is this due to the small rodents abundance in rice fields, or is this also related to the native vegetation remnants proximity 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 ocelots population size was estimated based on annual camera-trap samples obtained at 45 to 60 locations distributed among the different environments range 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 animals total number 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 photos database 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

population size, such as survival, longevity, birth and mortality.

Preliminary project data analyses show that the ocelots population density is between 29 and 66 individuals per 100 km² (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 sur-

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 ocelot prey. The live traps were distributed among multiple locations in agricultural and native habitat areas. The small mammals captured were sexed, 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



Foto: Érica Gomes

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

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

vey 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

models were used to estimate population densities and species abundances in the sampling areas.

From a total sampling effort of 9,480 trap-nights, 314 individuals from 9 species were regis-

tered. 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 (*Necomys 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 ocelot and other wildlife health investigations, field procedures included capturing and anesthetizing of medium-sized carnivores for biometric measurements, clinical examinations and biological samples collection, 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

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., a fat and muscles evaluation 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 other individuals

evaluated. On average, ocelots were infected by 6.7 hemoparasites per animal. Crab-eating foxes infections 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).

(9.4 kg). A large 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 ocelots maintenance and abundance, due to the small rodents large population in the fields. On the other hand, it appears that con-

tact between parasites and hosts may be increased due to the rice fields – both for prey and predators, potentially increasing the parasite transmission rate.

These factors may explain the poor health conditions observed for many captured animals, but further investigations are needed. For example, a relevant factor to consider is the agrochemicals use, a common practice in many agricultural areas. These products can weaken immunity in exposed individuals, and therefore have the potential to negatively affect the animals health 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 agrochemical exposure and prey species parasites effects. Field activities will also continue with felines using GPS collars annual monitoring. Focused on ocelots and small mammals populations, 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 improve production areas management. The aim is to reconcile agricultural production goals with the Pantanal's precious biodiversity conservation.

All the carnivores evaluated showed positive, but low titer, serological test results for rabies. These results indicated exposure to the virus without clinical rabies manifestations, 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 rabies manifestations).

With respect to *Leptospira* sp., both preva-

lence and titers were high, with about 70% of individuals positive. Important leptospirosis symptoms 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 humans, domestic animals and wildlife health.

SUSTAINABILITY

NATURAL PRODUCTS COMMERCIALIZED CONSCIENTIOUSLY

Photo: Wetlands International

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

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

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

In addition to concerns about natural resources management, discussions on sustainability should include a society's problems holistic view. Beyond the environmental, economic and social factors tripod, other complementary aspects to consider include: cultural, ecological, territorial and political (national and



**Small-scale tourism favors
low-impact activities**

international) dimensions. In this manner, sustainable businesses will value people, their knowledge and customs.

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 human presence in the Pantanal – registered since the 16th century – includes several ethnic indigenous groups (Guai-kuru, Kadiwéu, Aruak, Guarani, Guató, Meridional Kaiapó, Paya-

guá) among other non-indigenous people, such as riverine and quilombola communities. Throughout the occupation history, 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, customs 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 large-scale cattle ranching and agricultural operations expansion. 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 varying sizes rural properties, 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 production systems sustainability, either through monetization strategies, origin recognition or through the creation of eco-friendly (sustainability) labels that increase a product or service profitability.

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 Corumbá (MS) and Cáceres (MT) municipalities.

Commercializing honey from the Pantanal is also being considered as a diversifying production means. It stands out as a sustainable activity due to the wild plants species variety 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 Instituto Industrial Property National Institute (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 productivity maintenance with natural environments protection. 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 products consumption

associated with these programs is linked to educational background and greater awareness on the consumers part. 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 of view, this is the best way to guarantee effective development of sustainable production.

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 multidisciplinary scientific knowledge value. 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).

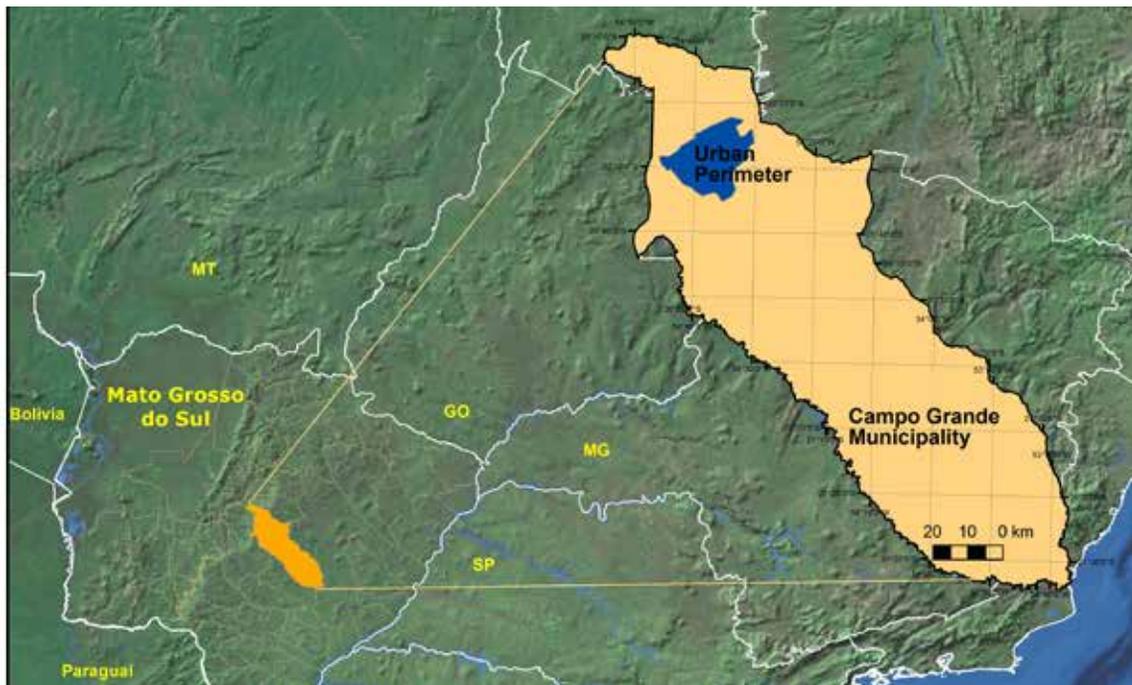
In the Mato Grosso do Sul state (MS), the government began working on statewide zoning in 2007. As a foundation, the state adopted the ZEE matrix prepared for the Legal Amazon (the geographic area containing all nine states in the Amazon basin) by the Territory Management Laboratory at the Rio de Janeiro 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 Mato Grosso do Sul State Territorial Management Program (PGT/MS) and approved the Ecological-Economic Zoning first phase. 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 an urban planning second round for the municipality, called the "Director Plan", 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 600 meters average elevation. 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 municipality total area is 8,082 km², 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 Campo Grande ecological-economic zoning (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 natural capital maintenance and environmental services provided by ecosystems and (3) for promoting ecological, economic and social sustainability with the aim of reconciling economic growth and natural resources protection, favoring present and

future generations and recognizing the intrinsic value of biodiversity and its components.

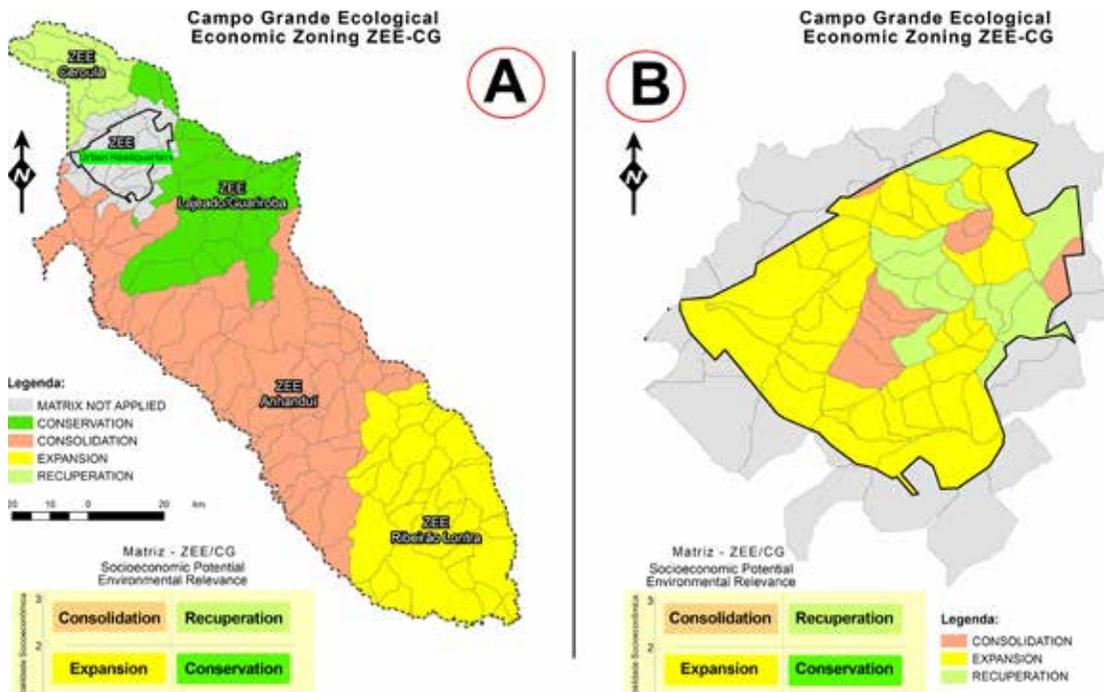
In an unprecedented way, ZEE/CG was implemented throughout the entire municipality, uniting zoning plans for rural and urban areas. Through this instrument, municipal administrators and public and private parties are now better able to understand and carry out territorial planning and organization in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

The Campo Grande ecological-economic zoning 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 basin natural relief, available cartographic materials for delimiting areas, and the urban and rural areas spatial configuration.

Two other important results from the law include: the creation of 5 zones, based on socioeconomic potential and environmental relevance, and a territorial planning matrix establishment. 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 envi-

ronmental 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 urban environ-

mental planning development, 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 FIRES BLEAK LEGACY

The main lesson from the 2019 and 2020 catastrophic events 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 the preventive fire use in Pantanal, out of dry season

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 prolonged

droughts and associated increases in fire hotspot numbers monitoring, as observed during 2018, 2019 and 2020. Historically, the Pantanal has undergone even longer drought periods, 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-effective.



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 fire spread rate. This is common knowledge. However, a lack of clarity about the legal steps and procedures for fire management

tinual 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

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 con-

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 fire ignitions control depends on education and information and is everyone's responsibility 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 Afro-Brazilian slaves descendants). 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 Pantanal natural flood pulse was one of the main factors responsible for the increase in fires numbers and the burned areas magnitude 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 Upper Paraguay Basin (BAP) rivers. In 2019 and 2020, rainfall was 25% and 40% less than average, respectively. These alterations in-

fluenced 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 underground fires continued burning 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 Pantanal flora composition and diversity, 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

communities lost large portions of their lands that compromised their food, work and income sources. 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

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 other adults from the herd carcasses.

Many ranchers and local

Fire brigades, trained and equipped (top), prevent large fires (side page)

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 smothering the flames) and courage. Sadly, some died sur-

rounded 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 commu-

nities impacted by the fires and wildlife rescue teams working during post-fire periods. In the Bolivian Pantanal, the number of fires was greater in 2019. In 2020, the fire hotspots number was above average, but they were concentrated in the Chaco ecosystem. The two most affected wetland reserves were the Otuquis National Park and

fires, which resulted in deaths and the homes, vegetable gardens, and livestock corrals losses. In the Bolivian Pantanal, the number of fires was greater in 2019. In 2020, the fire hotspots number was above average, but they were concentrated in the Chaco ecosystem. The two most affected wetland reserves were the Otuquis National Park and

round. They act as a barrier to slow or stop the wildfire progress, 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 only solutions are 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 country offices. They circulated daily reports on wildfire movements and when necessary, set up emergency fire management groups. To try to minimize the wildlife loss 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 or a 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, cap-



Photo: Silas Ismael

nities impacted by the fires and wildlife rescue teams working during post-fire periods.

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 Río Negro National Park, the Los Tres Gigantes Biological Reserve and the San Rafael community. The community was hard-hit by the

the San Matías Integrated Natural Management Area, both close to the Brazil-Bolivia border

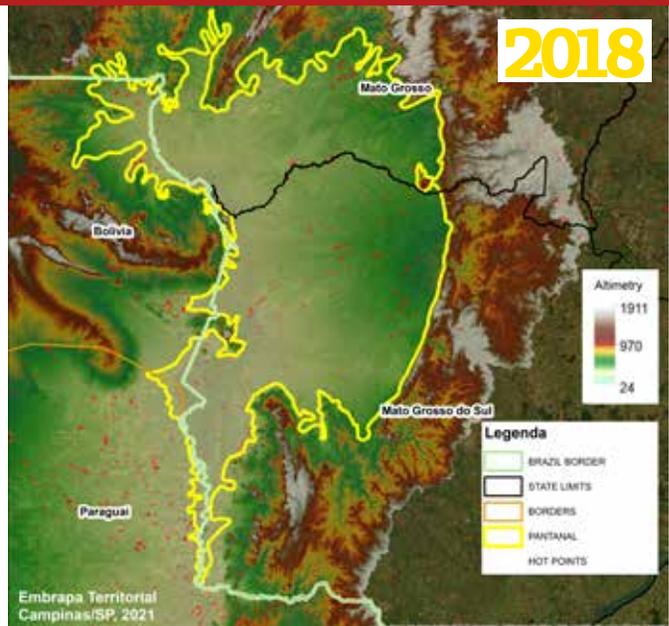
In the Brazilian Pantanal, where access via primitive roads and trails is harsh, fires are generally difficult to control. In addition, firefighting resources from the federal government arrived far too late. Firebreaks lack was another factor that did not help slow down the fires. Firebreaks (aceiros) 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 wildfire progress, 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 only solutions are aerial firefighting or heavy rains.

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FIRE POINTS IN THE INTERNATIONAL PANTANAL

Territorial distribution of the total hot spots detected in the international Pantanal by NASA's MODIS-Aqua reference orbital monitoring system throughout 2018, 2019 and 2020



ture equipment, animal 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 carcasses abundance 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 need to find unburned vegetation areas, possibly increasing competition between species. Researchers, landowners, NGOs, volunteers and tourism inn own-

ers set up 160 feeding station platforms and water sources for the surviving wildlife. However, in some locations, stations have attracted predators due to the potential prey concentration, 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



snake skeleton

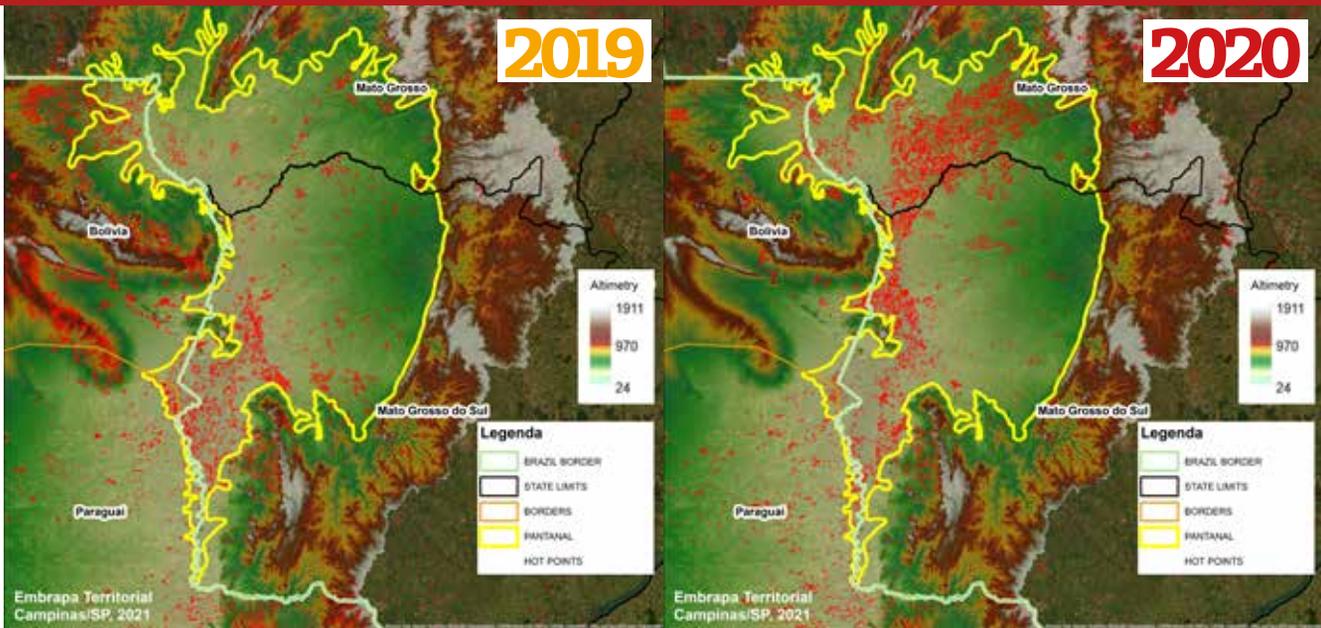
Photo: Silas Ismael

have been decimated. Although “invisible” to most people, they perform essential ecosystem services such as soil aeration / fertilization, organic matter decomposition, pollination, etc. Their absence will have significant ecological impacts as the vegetation and wildlife populations slowly begin to recover.



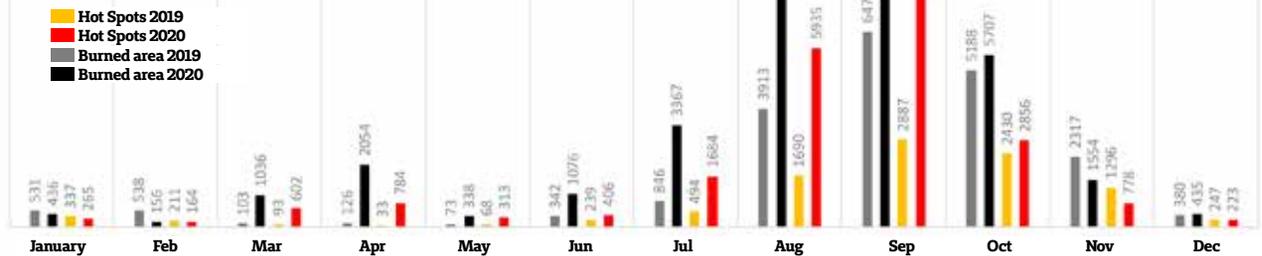
Greater rhea (*Rhea americana*)

Photo: Bruno Carvalho



WILDFIRES IN 2019 AND 2020

Figures related to the Pantanal biome in Brazil, according to INPE, based on the hot spots detection by the Acqua / NASA system and burned areas estimations (km²)



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

cies, 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 natural vegetation mosaics maintenance and fire prevention management measures – should be widely promoted, disseminated and incorporated into the Pantanal inhabitants and visitors daily routines, this includes 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 be-

come 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 2019, a fire started on a REC's neighboring ranch 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 dry organic material accumulation. Unfortunately, the flames



Photos: Bruno Carvalho

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

At the Caiman area, there are 98 registered nests, 51 of which are natural and 47 artificial. Similar to other macaws, the hyacinth 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. Numerous macaw

tree cavities are disputed by other birds, so the cavities make up an important biodiversity component.

Hyacinth macaws are large birds and fast fliers, but when the fires arrived, they were in their reproductive period peak with eggs or newborn chicks. Frequently used nesting sites and an entire hyacinth macaws generation was threatened. The fire spread quickly and for 16 days all the ranch employees, hotel staff and researchers were fighting the out-of-control fire nightmare. 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 phaler-*



ata) 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 among birds in the Pantanal.

Almost half (49%) of the active hyacinth macaw nests suffered some impact. In some cases, the fire reached the nest site and both eggs and chicks were killed (this is called “direct failure”). In other cases, the fire did not burn the tree, but offspring mortality was caused by heat and/or smoke (“indirect failure”). Also, the fire reached the nest surroundings, but not the cavities and at least one of the chicks survived (“direct interference”). And there was also the opposite: 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 metallic straps sheets to reduce the eggs and chicks’ predation 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.

Fire impacts monitoring 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 offspring survival were evaluated. For example, the ripe palm resources loss, such as acuri and bocaiúva; the decrease in fruit production and the monodominant palm formations loss, such as *acurizais* and *bocaiuvais*; and the increased adults and offspring predation rate. Monitoring data on fire impacts will be necessary for several years in order to determine the effects on plant and animal communities. And this shall include 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 fire-related losses effects 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 highly-combustible decomposing vegetation accumulation 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 hyacinth macaws concentration in the Pantanal.

Photo: Thamy Moreira



Metal straps and weeding protect nests (top and side page right). Acuri coconuts matured one year later (center)

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, local information indicated that a fire started at an Indigenous Territory, home to the Boe people (formerly called Bororo). It was raging and fierce. Help to fight the fire came from other farmers, volunteers, and



Photo: Neiva Guedes



Photo: Bruno Carvalho

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 savannah-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 few vegetation patches 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 fruits abundance 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, the active nests were all in areas with moderate-intensity fires, often burning at the tree base, but without flames reaching the nesting cavity. Based on the age of fledglings, researchers concluded that they all were born after the fire. Some nests were preserved thanks to the vegetation clearing (fire-break) around the trees, made

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 some water and

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. All the



in January 2020. This management strategy reduces the fuel amount for the fire and the height of the flames.

Although many hyacinth macaw palm resources from *acurizais* and *bocaiuvais* were destroyed, the adults remained on the ranch. A total of 736

acuri and *bocaiúva* nuts piles 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.

trees trunks with active nests were lined with metallic straps sheets. Artificial nests were re-installed to replace damaged ones, and additional nests were placed throughout the region to compensate for the fire damaged natural cavities loss.

Natural nests in trees need

maintenance to increase the tree cavity longevity. This includes clearing combustible vegetation at the trees bases. Installing camera traps post-fire helps monitor the general behavior and birds and wildlife movements. It is also important to monitor the natural key plants recovery such as *acuri*, *bocaiúva* and *manduvi* (*Sterculia apetala*), the latter which the



Photo: Bruno Carvalho

hyacinth relies on almost exclusively for nesting. If the data indicates low post-fire regeneration of these key species, then seedlings and seeds planting shall be initiated to help restore these essential resources.

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 to be in good condition in order to defend themselves

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

against predators.

In the wake of the wildfires that advanced across large Pantanal portions, 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 individuals or species dispersal. 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 new generation survival rate.

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 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 society support 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 2019 fires and drought. During this critical period, the Pantanal floodplain also suffered – and continues to suf-

fer – from the deforestation effects. 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 these impacts' severity is the plant-animal interactions disruption.

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 plant-pollinator interactions importance to

vation strategies and decision-making that ensure the survival and resilience of all plants and animals are needed. Just to remember, resilience, is an ecosystem and/or population capacity to respond to a disturbance by resisting environmental damage and recovering quickly.

In the dry and burned Pantanal, where the slow healing

Mutualistic interactions are widespread in nature and have played a major role in the life diversification 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 understand the communities structure and functioning. 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 species subgroups formation that interact more with each other than with other species in the network. Such species subgroups are called modules. They can be formed due to different processes,



Photo: Camila Souza

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

ecological communities in the Pantanal. This is especially relevant for the current recuperation phase, during which appropriate conser-

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 flowers and fruits production, and in return, they attract animals. Animals move plant genes across the landscape and their service is rewarded with food.

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 resources availability offered by flowers to their pollinators, such as the flower shapes diversity, nectar/pollen/oil types and color, can influence these interactions

included flooded areas with monodominant formations of *paratudo* (*Tabebuia aurea*) and *canjiqueira* (*Byrsonima cydoniifolia*) and riparian forest formations representative of the Miranda subregion in



Photo: Karen Santos

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

structure and dynamics.

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

the southern Pantanal.

Three Pantanal communities diurnal plant-pollinator interactions 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 modules' organization were evaluated. Did the Pantanal dry and wet seasons affect the network structure? Were there 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%). A tree (*Inga vera*) was responsible

for 9.3% of the interactions, followed by the water primrose *Ludwigia elegans* (5.9%), and the "paratudo" *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 floral resources abundance, 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 floral resources availability

and the interactions between plants and pollinators.

These results prompted an evaluation of the possible wildfires impacts 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 flood-

plain. 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 km² and 8,000 km² of native vegetation will be lost on the Pantanal floodplain and in the surrounding highlands, respectively.

These vegetation loss projected values 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 km² of native vegetation loss in the Pantanal is concentrated in a small transitional area between the floodplain and highlands called the “Pantanal Native Vegetation Loss Arc”.

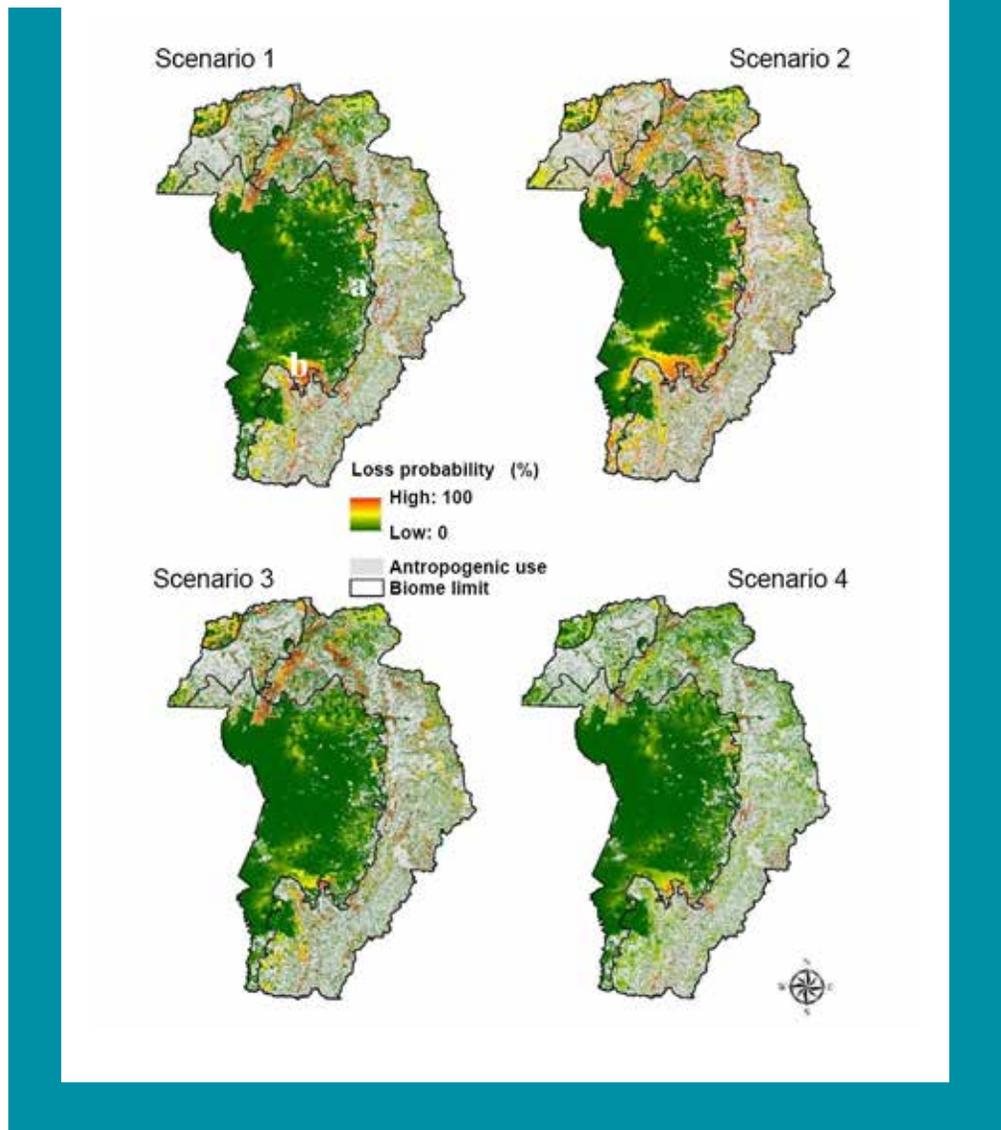
In two of the areas located in the “Arc”, native vegetation is already limited to steep hillsides and slopes and Permanent Protected Areas (APPs). In another area of the “Arc”, the river is not protected by a riparian APP as required by the Forest Code.

In the “Arc”, the vegetation loss occurs mainly through native habitat con-

version to planted pasture and crops. Landowners find this region ideal for native habitat conversion, because it does not experience the typical Pantanal flood pulse. 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 crops or planted pastures expansion and environmental laws weakening – by 2050, native vegetation loss could reach 12,900 km² and 10,000 km², 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

PANTANAL NATIVE VEGETATION LOSS ARC SCENARIO

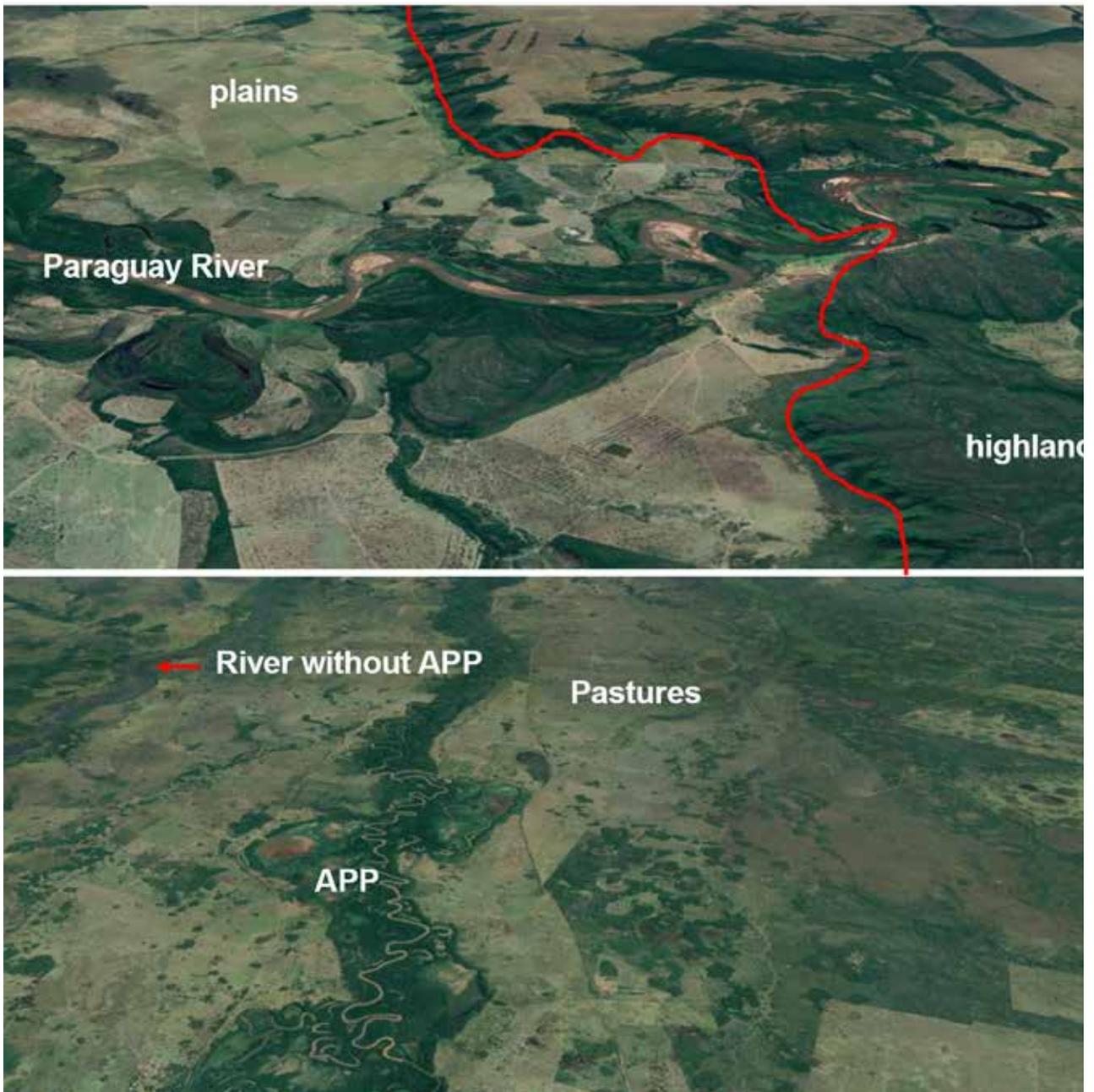


don't indicate only negative scenarios. They also point out positive outcomes such as the biodiversity conservation value associated with an increase in protected areas and compliance with envi-

ronmental 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 tra-

jectories, 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 biodiversity conservation 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 ecosystem services preservation.

Watch a video illustrating land use changes in the “Pantanal Native Vegetation Loss Arc”. Available from the link: <https://tinyurl.com/y28xpl6b>.



TOURISM AND CONSERVATION

FISHES OF BONITO

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

BY JOSÉ SABINO AND LUCIANA PAES DE ANDRADE



Piraputangas wait for the fruits dropped by Capuchin monkeys

ated by the remarkably transparent waters.

That day – and the information exchange richness – 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 his studies object, 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 animal behavior study.

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.

Just after dawn, a gallery forest trail led two researchers and a guide to the Rio Formoso banks in Mato Grosso do Sul. It was July 1995 and the Serra da Bodoquena crystalline rivers had piqued two scholars’ interest. 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 window cre-

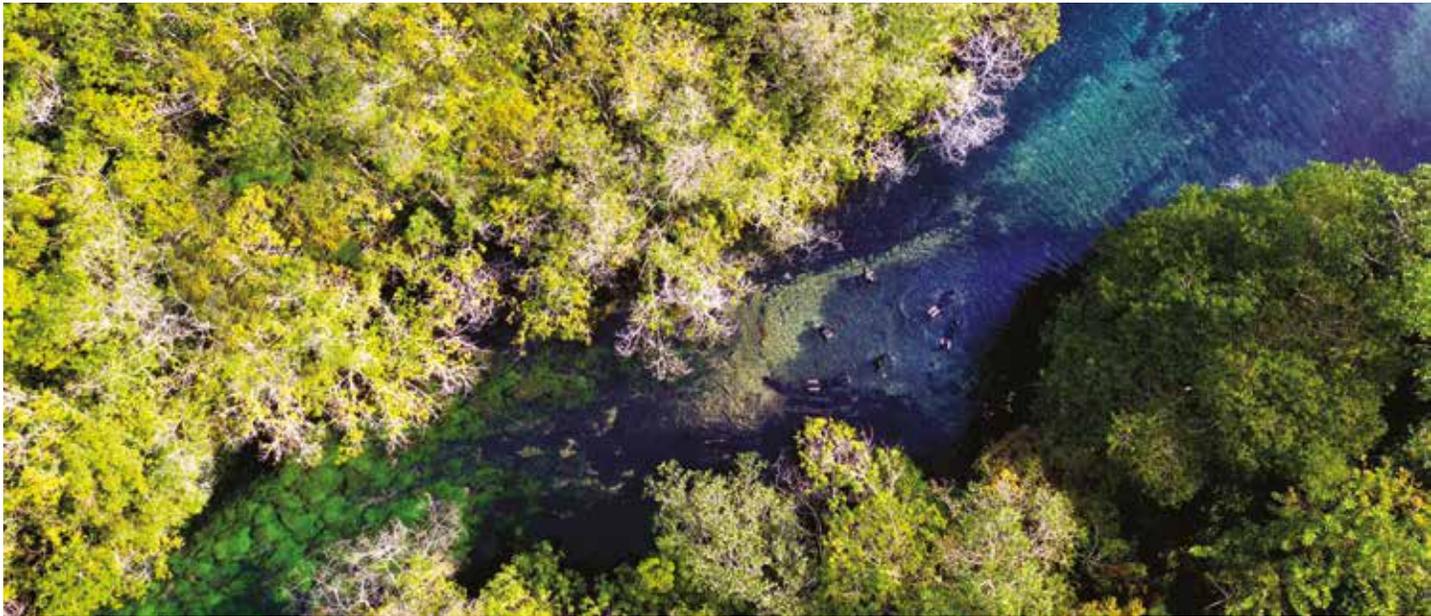


Photo: Olivier Lucanus

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 Rio Formoso source. This time, a tip about the catfish existence 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 inland waters. This number will most likely continue to increase given the still limited knowledge 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 Serra da Bodoquena region crystal clear waters provide a great opportunity for observing and gaining knowledge about Brazil’s aquatic biodiversity.

Studies in the region progressed from basic fish fauna surveys to more applied investigations on particular species ecology and conservation. Over the past 20 years, researchers based at the Anhanguera-Underp University created an ex-

tensive collaborative network comprised of specialists from Brazil and abroad. Publications contributed by this group have expanded our biodiversity knowledge and promoted this extraordinary natural heritage region conservation. 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 are no longer considered just food or “smelly” animals, but are 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 thousand tourists received annually in the region, approximately 60% (120 thousand) opt



putangas”, 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

In the Bonito transparencies, tourists float in Olho d’Agua (left) and watch big fishes, like the “dourado” (right)

for floating tours into the transparent waters, made with the guides support, snorkeling equipment and neoprene clothing.

Floating tours in the Bodoquena springs and rivers 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 monitoring methods and sustainability indicators development for this type of tourism.

The fishes are the stars. During a brief floating tour, it is possible to observe varying sizes, shapes and colors species: 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 visitors minds, whether scientists or tourists. Regulations for visitors interacting with fauna have also changed: until the early 2,000s in the Municipal Balneario (swimming area) of Bonito, tourists were allowed to feed the fish. This mainly attracted “pira-

19% in the examined specimens’ weight. At the request of the State’s Public Ministry and the Bonito municipal government, 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 São Paulo University (USP), the Mato Grosso do Sul Federal University (UFMS) and the Smithsonian Institution, the Fishes of Bonito Project members carried out an extensive fish species inventory from the Serra da Bodoquena region. The resulting list reached 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 education and environmental awareness areas. Through partnerships with floating tour organizers, such as those from the Recanto Ecológico Rio da Prata and Rio Sucuri, educational booklets and underwater guides about fish species were produced. 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 video documentaries production.

around conserving or economically exploiting natural areas. Carried out following regulations for visitation limits established by scientific studies, it can work. In the Bonito case, 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 visitations result.

However, the beauty and scientific importance of the region are being threatened by factors other than controlled tourism. Since 2012, the agricultural commodities increasing value and demand has intensified land use change characterized by pastures and native vegetation conversion to crop plantations. As a result, there are already disturb-

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 around 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 society seg-

In order not to disturb the crystal clear waters, tourism is controlled. But agricultural activities still need rules

Photo: José Sabino



Tourism based on biodiversity observation has become increasingly popular, especially because it is recognized as a solution for resolving conflicts

ing trends notices: rivers where visibility reached 50 meters in the past currently may become cloudy from sediment runoff after rainfall events. Reports of

ment or another, but of imposing legislation that protects the Bonito region, especially the Formoso and Prata rivers and all the associated biodiversi-

ty. 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

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 possible environmental impacts mitigation. Such a consensus is essential to prevent impacts and

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

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 intention to make specialists networks available to local communities in order to increase knowledge about regional biodiversity, encourage honest dialogues and resolve conflicts with the aim of Mato Grosso do Sul state's magnificent environments conservation and sustainable use.

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.

importance of protecting these unique environments.

The natural resources use, whether for tourism or agriculture, can generate impacts that

irreversible damage to sensitive and unique environments such as those in the Bonito region.

There is little point in creating visitation protocols for mini-

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



Photo: Matheus Jeremias Frtunato

KEEPING AN EYE ON WILDLIFE

Wildlife must be monitored to ensure the species health and conservation

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

The health concept – when referring to wildlife – must be discussed and understood as a system composed by elements and relationships capable of enabling the species perpetuation, the populations maintenance, and diverse communities' coexistence 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 well-being, disease and productivity concepts, either referring to individuals or populations.

As is the case for humans and domestic animals, and even wildlife, individual health assessments are as-

sociated 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 biological materials sampling for laboratory tests – whether hematological (blood), biochemical (metabolism), toxicological (toxic substances and poisons) and / or parasitological (mites, ticks, lice, worms, etc.) – contributes to an animal health's detailed assessment.

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 wildlife populations evaluation. But both field and laboratory analyses must be evaluated together. And care must be taken in clinical evaluations once some parasitized animals may show non-specific symptoms or no clinical symptoms at all. Attention must be given to the laboratory results interpretation 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 wild animals' containment. Furthermore, the stress levels 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 humans proximity). 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 hu-

man and logistical resources associated with the lack of roads, communication, electricity and security, and with

viruses and fungi) have been recorded from native mammals in the Pantanal biome.

Despite being considered



Photo: Kamila Mechi



Photo: Carolina Garcia

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,

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, parasit-

ism should not always be considered a harmful condition caused by organisms that survive at their host's health expense. 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 host physiological conditions and alter the vari-

ous bodily functions balance 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 virulence degrees 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).

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 wild animals' reintroductions 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 infection risk by new parasites and/or the multiplication risk of undetected parasites present in low numbers in animals with subclinical conditions (without the disease signs and symptoms). Similarly, the domestic animals introduction – such as dogs and other pets from urban areas, or even cattle, brought from cities and other country areas/regions 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 populations' resilience and sustainability. In this context, the scientific community must work together with civil society organizations in order to encourage the public policies development and application that promote conservation. These actions will ensure the wildlife species, populations and communities health, and guarantee ecological processes continuity in the Pantanal.

Photo: Carolina Garcia



Monitoring mammals in Nhecolândia: blood collection and physical examination in coati (above), collection of the ocelot parasites (left) and the ocelot head with scabies signs (right)

LANDSCAPE MOSAIC

THE BODOQUENA ENVIRONMENTAL GUARDIANS

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

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



Of the almost 4,000 terrestrial mammalian herbivores species on the planet, only 74 species are classified as large herbivores, including the Brazilian tapir (*Tapirus terrestris*), the largest remaining native Neotropical region herbivorous mammal. As is the case for the tapir, more than half of these 74 species are listed as endangered, while the rest of the species populations are in de-

clination to the rainfall regime. These extinctions also led to their predators' disappearance, 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 (Blue Lake Cave), where paleontological studies confirmed the giant sloth (*Eremotherium laurillardi*) and the carnivorous saber-toothed tiger (*Smilodon*

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 fruits diet, such as many small mammals, including the elegant rice rat (*Euryoryzomys*

Photo: M. Mamede



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

cline. Some are iconic species, such as black rhinos (*Diceros bicornis*), common hippos (*Hippopotamus amphibius*) and African elephants (*Loxodonta africana*).

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 re-

populator) existence.

But, 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*,

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 turning over plant materials and soil habit while looking for food creates and physically modifies habitat structure. Furthermore, they can influence vegetation



Photo: M. Mamede

Photo: Jeffrey Himmelstein



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

The Serra da Bodoquena, located in the Upper Paraguay River Basin highlands, has historically been and currently remains a paradise for herbivorous mammals! Over many, many years, the variety of habitats with their vegetation diversity 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 landscape variety that include agriculture and/or livestock production areas, and a wide native vegetation patches with different remaining cover. By evaluating the herbivorous mammals' response to this scenarios range, 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 small, medium and large herbivorous mammals species living in the region, all responding in unique ways to the forest cover percentage remaining in the



Photo: M. Mamede

To observe the marsh deer helps preserve the Bodoquena landscapes

landscape.

This is because these animals have different behaviors and requirements that determine their habitats use. 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 herbivorous mammals environmental responses 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 different 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 the Cerrado and Pantanal biomes land-use management. Mato Grosso do Sul is one of the Brazilian states where more than 50% of the 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 ecological system resilience, its biodiversity and ecosystem services. The challenge is to implement conservation strategies that maximize biodiversity through agricultural practices requiring minimal deforestation and promoting degraded areas restoration. In other words, articulate conser-



vation 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 forest fragments and corridors con-

servation. 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 native habitats fragmentation is increasing.



Photo: Gabriel Oliveira de Freitas

REDISCOVERY

A HAPPY REDISCOVERY

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 São Paulo University (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 the cinereous tyrant record 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 (Paraná state).

The Corumbá region is comprised of a diverse landscapes gradient influenced by different ecoregions in Brazil and neighboring countries. Environments range from rivers, wetlands and lakes to

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, large numbers sightings of these species are possible.

Even though Mato Grosso do Sul has a huge fauna diversity, some species are only

(*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



Photo: Gabriel Oliveira de Freitas

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.

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

found in Corumbá and along the western border with Bolivia and Paraguay. This is the case for the green-cheeked parakeet

Grosso do Sul.

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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