VNiVERSiDAD D SALAMANCA

DETERMINATION OF THE VALUE OF LIVESTOCK LANDSCAPES IN THE CONSERVATION OF BIRDS AND, MEDIUM AND LARGE-SIZED MAMMALS IN THE PARAGUAYAN DRY CHACO

DETERMINACIÓN DEL VALOR DE PAISAJES GANADEROS EN LA CONSERVACIÓN DE AVES y MAMÍFEROS MEDIANOS Y GRANDES DEL CHACO SECO PARAGUAYO

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Memoria presentada por la graduada en Biología Andrea Weiler de Albertini para optar al título de Doctor en Biología por la Universidad de Salamanca.

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Área de Ecología

El Doctor Don Fernando Silla Cortés, Profesor Titular del Área de Ecología de la Universidad de Salamanca

Certifica que:

la Tesis Doctoral titulada "Determination of the value of livestock landscapes in the conservation of birds and, medium and large-sized mammals in the Paraguayan dry Chaco (Determinación del valor de paisajes ganaderos en la conservación de aves y mamíferos medianos y grandes del chaco seco paraguayo)" que presenta Dña. Andrea Weiler de Albertini para optar al título de Doctor en Biología por la Universidad de Salamanca, ha sido realizada bajo su dirección, en el Área de Ecología de la Facultad de Biología de la Universidad de Salamanca y reúne todos los requisitos científicos y formales necesarios para su defensa.

En Salamanca, a 13 de julio de 2023.

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Somo una especie más de este planeta.

Somos una especie plástica, invasora y con la capacidad de modificar profundamente nuestro entorno.

Tenemos la facultad de analizar situaciones y proponer soluciones

Abro el debate con las siguientes reflexiones…

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1. INTRODUCTION

Human development and biodiversity

All around the world, land cover and land use change has modified the earth ecosystems causing degradation of soil and water resources (McGill, 2015; Newbold et al., 2015), and alterations of many natural processes (Stanimirova et al., 2022) like carbon cycle (Ahlström et al., 2015; Baumann, Gasparri, et al., 2017; Pan et al., 2011; Tagesson et al., 2020) and water cycle (Bosmans et al., 2017; Haddeland et al., 2014). As a consequence of habitat loss and degradation, biodiversity has suffered moderate to severe declines as human population growth and intensify land modifications (Beninde et al., 2015; McGill, 2015). Predictions based on biodiversity responses to agriculture found that up to 30 % of species richness may be lost across the tropics, especially in countries with week national conservation schemes, low conservation spending and high agricultural growth (Kehoe et al., 2017).

Worryingly, many countries of Latin America fulfill those conditions. The continent has been an epicenter of land cover conversion by several consecutives' decades, mainly for soy bean and cattle production activities (Gasparri et al., 2013; Stanimirova et al., 2022). As a consequence, species numbers under local and regional protection lists increases in the continent (Asociación Paraguaya de Mastozoología & Secretaría del Ambiente, 2017; IUCN, 2023a; Martinez et al., 2020; Motte et al., 2019). This scenario has arising experts concern for the high extinction risk of many rare and endemic species (Brito, 2008; Maciel et al., 2023). In fact, Latin America countries has suffered local extinctions of species due to human pressure, as is the case of jaguars already extinct in Uruguay and El Salvador (Swank & Teer, 1989). Moreover, 31 endemic species of the Neotropics are listed as extinct by the IUCN (IUCN, 2023a).

Given this scenario, traditional conservation practices, such as site-based conservation by themselves, are insufficient to conserve biodiversity and ensure ecosystem services (Visconti et al., 2016). New efforts are needed to guarantee fair access to food and conserve biodiversity, such as the establishment of policies to push towards more sustainable productive systems. There are many opportunities for governments to enhance protection of the biodiversity inside their territories, considering the interaction between habitat loss and agricultural expansion (Dietz & Adger, 2003). Some effective actions are the regulation of agricultural expansion (Chaplin-Kramer et al., 2015), increasing in productivity (Acevedo et al., 2018), reducing food and crops waste (Guerrero-Pineda et al., 2022), the adoption of better production practices (Kremen & Merenlender, 2018) and educate consumers to be award of food impacts on nature (de Boer & Aiking, 2021), among others. However, to be effective, any action requires cultural acceptance and local adoption, so they have to consider each country socioeconomic and governance environment and its capacity to implement these strategies (Williams et al., 2021).

Paraguay, landlocked country in the heart of South America.

The Republic of Paraguay is a landlocked country located in the heart of South America, with an area of 406,752 km2. The country is divided from north to south by the Paraguayan river into an east and west region. Population is over 7 million people and more than 4 million reside in the capital city and neighboring areas. The country is bilingual having Spanish and Guarani as official languages and many scientific and common names of species have their roots in this native language.

From the biogeographical point of view, Paraguay is a large ecotone where five ecoregions converge, the Atlantic Forest, Cerrado, Humid Chaco, Dry Chaco and Pantanal (Dinnerstein, 1995) (Figure 1). From them, the Atlantic Forest and the Cerrado are within the Global 200 ecoregions (Olson & Dinnerstein, 1998), both ecoregions have been severity affected by deforestation due to agriculture, cattle ranching and wood market. As an example, between the years 1973 and 2000 Paraguay loss two thirds of its Atlantic Forest (Huang et al., 2007).

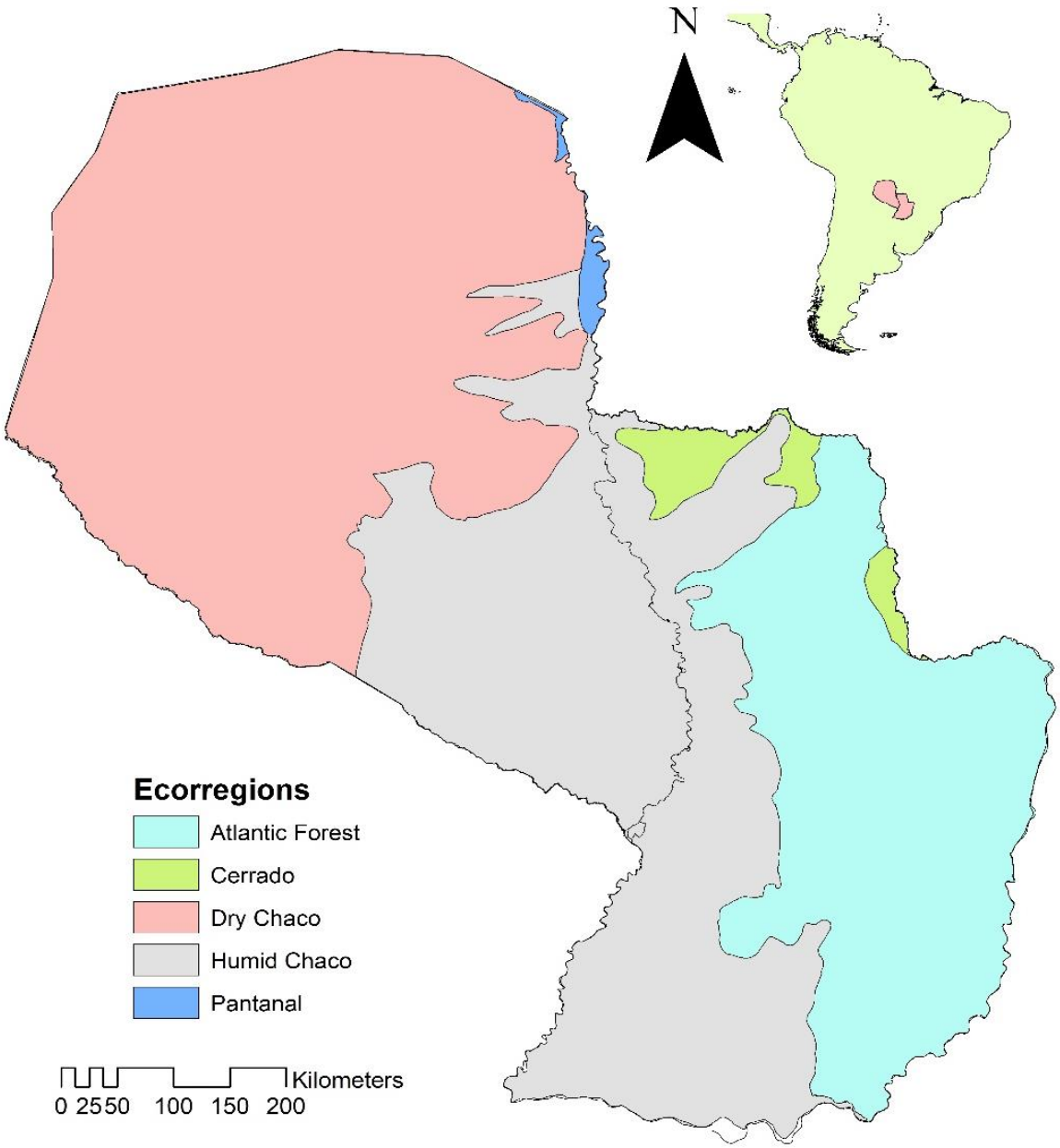

Figure 1. Ecoregions of Paraguay.

The country holds a rich biodiversity, with 181 species of mammals (Asociación Paraguaya de Mastozoología & Secretaría del Ambiente, 2017; De La Sancha et al., 2017a), 702 species of birds (H. del. Castillo et al., 2005; Narosky et al., 2022), 191 species of reptiles (Cabral & Cacciali, 2021; Cacciali et al., 2016; Cacciali & Ortega, 2023; Martinez et al., 2020; Smith et al., 2022) and 87 species of amphibians (Motte et al., 2019; Weiler et al., 2013). However, knowledge of the country distribution of the species is poor, with a gap of information, mainly on private lands. Modern literature of vertebrates in the country are primarily first species lists for localities (Cacciali et al., 2016; De La Sancha et al., 2017a; Núñez & Weiler, 2015), expansion of distribution ranges (Tabilo et al., 2020; Weiler Gustafson & Owen, 2021; Zaracho et al., 2017), new records for the country (Cabral & Cacciali, 2021; Cacciali & Ortega, 2023; Smith et al., 2022), and even new species for science (Cabral & Cacciali, 2021; Cacciali et al., 2018).

The National System of Protected Wilderness Areas of Paraguay is composed by 88 protected areas, from which 44 are public, 31 are private and 13 are autarchic (MADES/PNUD, 2020) (Figure 2). Furthermore, there are 5 Biosphere reserves in the country, 2 locally declared and 3 declared by UNESCO. It is important to remember that biosphere reserves are not strictly protected areas, the figure was established by UNESCO in 1974 as an alternative to manage the coexistence between human and nature in an appropriate way (*Biosphere Reserves*, n.d.), and they are more intended to favor sustainable development. On the other hand, not all the areas declare as protected by the government were bought or expropriated and simply remained in resolutions, as a result only 7% of the country is protected under Wilderness Area (MADES/PNUD, 2020).

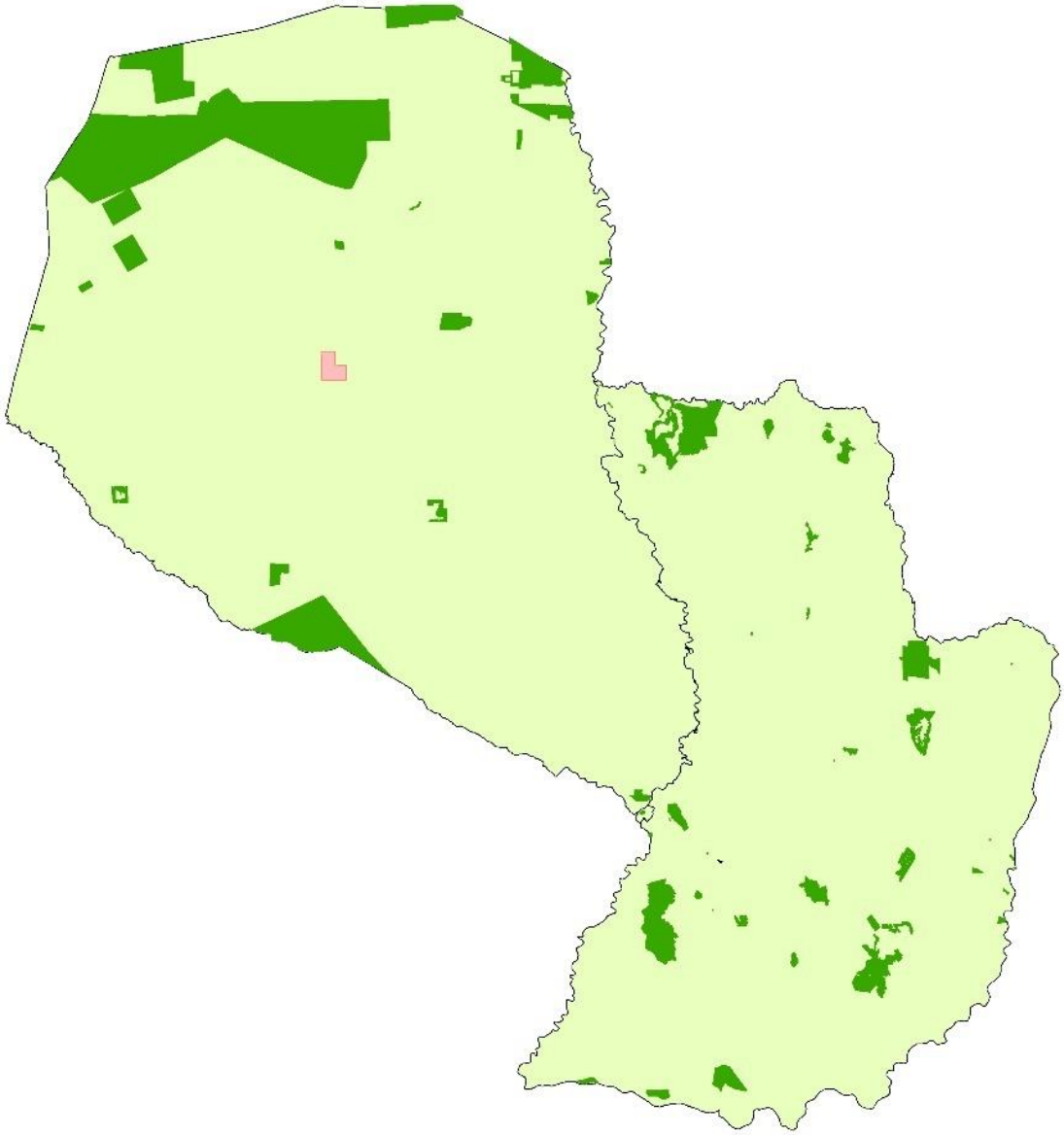

Figure 2. National System of Protected Wilderness Areas of Paraguay (SINASIP). Green: protected areas; Pink: Estancia Montania.

Paraguayan economy is based mainly on hydroelectric exploitation, agriculture and livestock production (González et al., 2019). The country has two large hydroelectric dams, Itaipu and Yacyreta, which generate more energy than the country uses, with the surplus being exported to Brazil and Argentina (Rivarolo et al., 2014). On the other hand, the country's soybean and beef production has increased significantly in recent years, to the point that Paraguay has

become the third largest soybean exporting country and the nineth largest meat exporting country in the world despite its small area (FAO, 2021).

Agricultural development has caused and continues to be responsible for the high rate of the transformation of ecosystems in favor of agricultural plots and cattle fields in the region (Fehlenberg et al., 2017; Gasparri & Grau, 2009; Prieto-Torres et al., 2022). In the 80's and 90's, Paraguay was the country with the highest global deforestation rate with an average of 444,810 hectares/year (M. C. Hansen & DeFries, 2004), forest losses were concentrated in the eastern region of the country where it eliminated 90% of the forest cover of the Alto Paraná Atlantic Forest, creating a highly fragmented landscape. This fact caused that in 2004 the National Congress sanctioned Law No. LAW 2524/04 known as the "Deforestation Law 0", which prohibits the transformation of forested areas to other land uses in the eastern region of the country, this prohibition continues to this day.

This scenario, added to the increase in international demand for food (Tilman et al., 2011) with the consequent rise in its price, has led to the focus of development turning to the western region of the country (Baumann et al., 2017). Where, the land use change rate has been gradually increasing, reaching around 1,000 hectares/day, making Paraguay the country to reach new records of deforestation rates, but this time in the Chaco ecoregion (Baumann, et al., 2017; M. C. Hansen et al., 2013).

The high rate of conversion of the xerophytic forest of the dry Chaco into cattle ranches implies profound transformations in the habitat of the species (de la Sancha et al., 2021). How biodiversity is coping with these transformations is a question poorly explore in Paraguayan Chaco. In this regard, few investigations addressed the response of wildlife to habitat perturbations (Areskoug, 2001; Saldívar, 2014; Thompson et al., 2021; Zaldivar et al., 2022a).

As agricultural frontiers continue to expand in the region, more research that provide light about biodiversity response are urgent.

Study Area Forest Cover

In an insight on satellite imagery from the year 2,000 of an area of 294,000 hectares surrounding Estancia Montania. From them, 157,000 ha corresponded to forest and 137,000 ha to other land covers (M. C. C. Hansen et al., 2013)(Figure 3). At that time, thorny forest still was the matrix of the landscape with 53% of the area coverage.

Figure 3. Forest cover of the area surrounding Estancia Montania in year 2000, Boquerón and Alto Paraguay Departments, Paraguay.

From 2001 to 2022 the area lost 51,600 hectares of tree cover; this represents a decrease of 33% of forest cover since 2000 (Global Forest Watch, 2023) (Figure 4). The tree cover loss is defined by the authors as stand level replacement of vegetation greater than 5 meters, within

the selected area. This term is not a direct synonym to deforestation, and may be due to change in both natural and planted forest, and does not need to be human caused as explained by the authors in the methodology. However, in this particular case, by the shape and the configuration of tree cover loss, those were intended to expand agricultural boundaries. The main losses in the area evaluated occurred until year 2014.

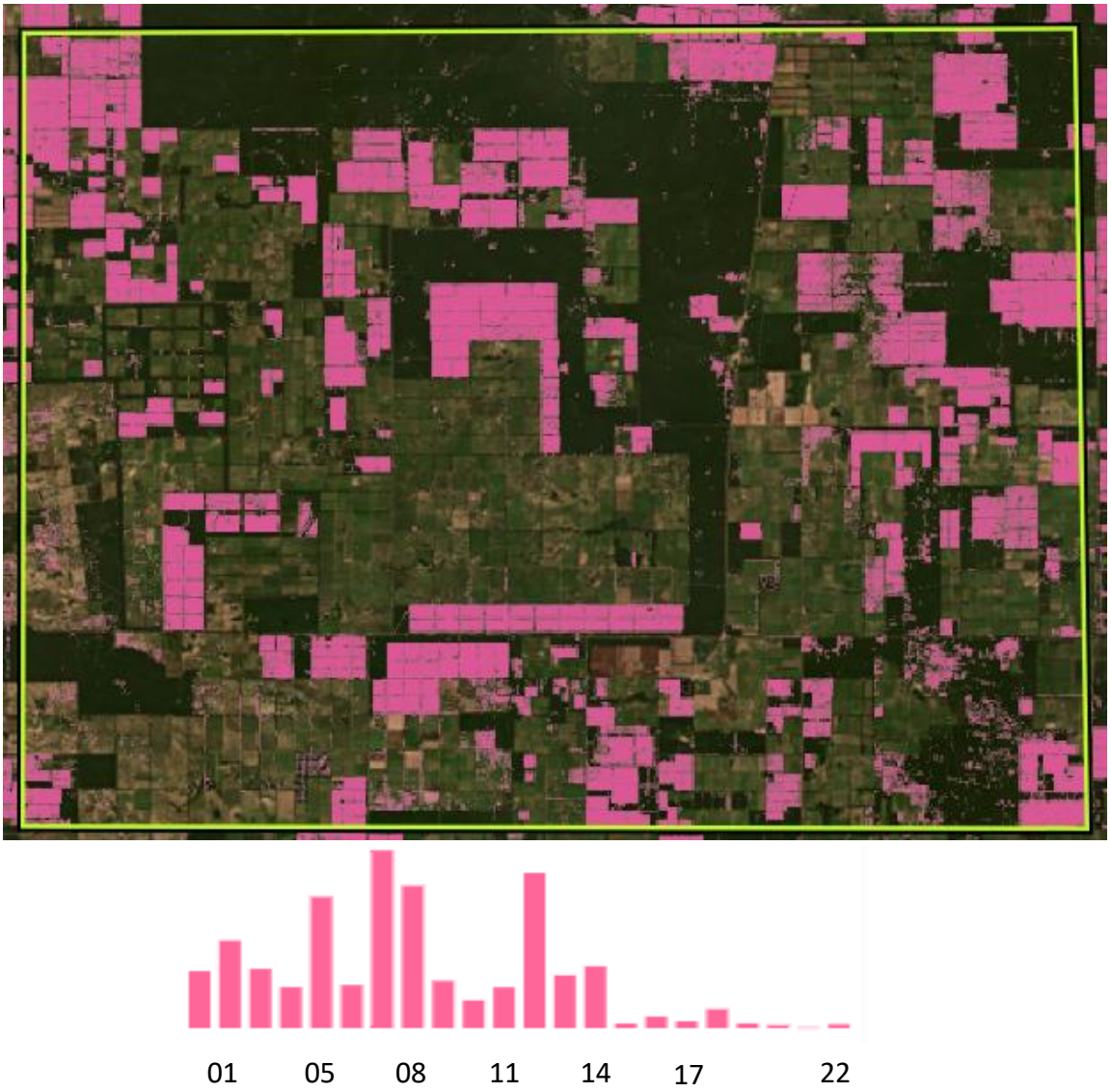

Figure 4. Left: Tree cover loss of the area surrounding Estancia Montania during the years 2001 to 2022, Boquerón and Alto Paraguay Departments, Paraguay. Right: Proportion of Tree cover lost by year.

In the middle of the polygon is located Estancia Montania, a 37,098 hectares ranch. Land use changes occurred in three phases, one from 1987 to 1996, another from 2006 to 2008, and finally from 2011 to 2013 when the ranch reaches the original configuration. Resulting in a total tree cover area of 14,658 hectares from which 10,500 ha constitute the forest reserve and the remaining 4,158 corresponds to forest strips. Most of the forest strips are inside the perimetral fence of the pastures, so they provide shelter to cattle during the hottest hours in summer time and the cold winds of the winter. Implanted pasture total surface is 22,440 hectares, and there are divided into six productive unities (represented in the map as lightened colors) (Figure 5).

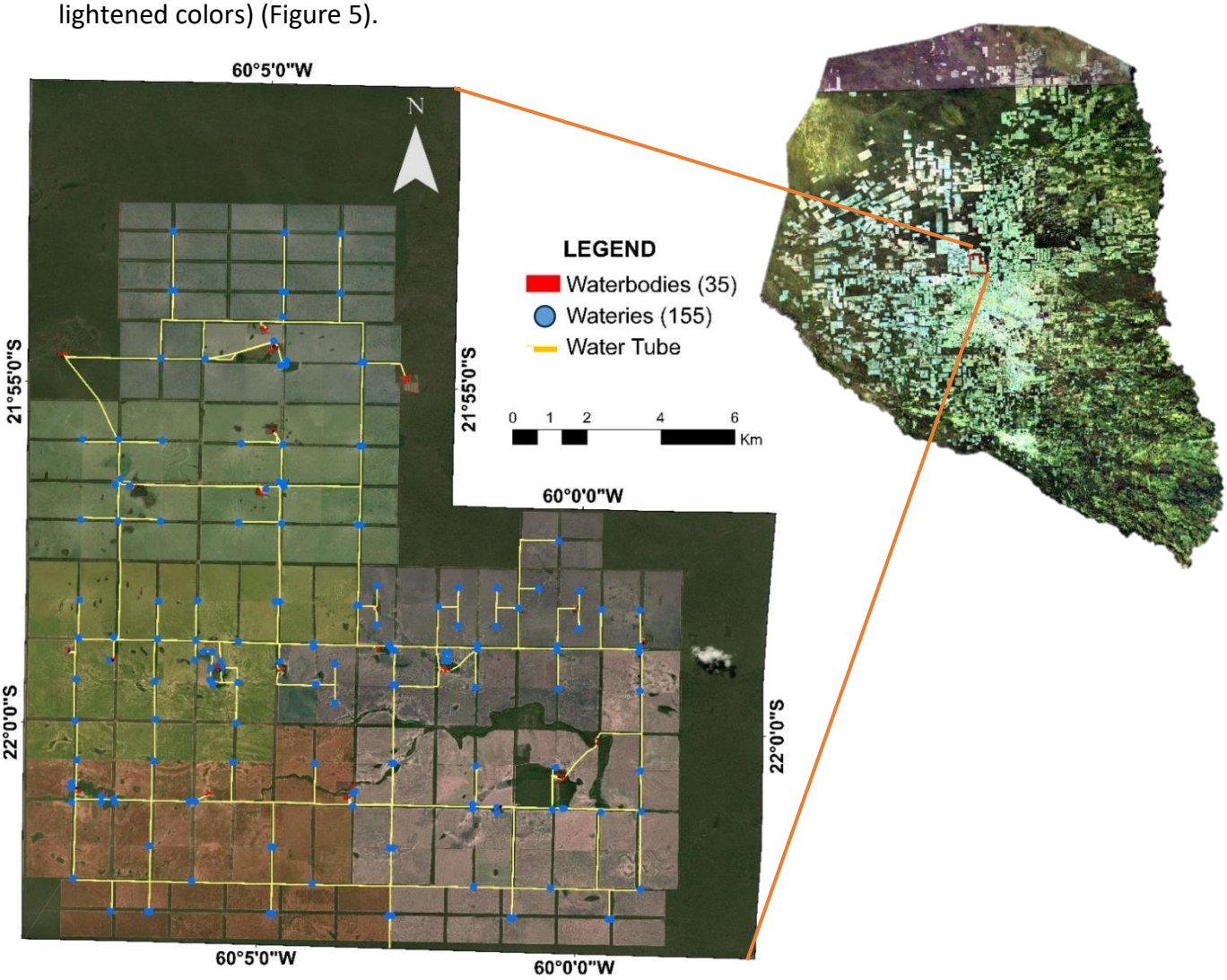

Figure 5. Land configuration of Estancia Montania

The ranch has thirty-five waterbodies, called “tajamares”. They gather water from the rain and stocked it in large ponds artificially constructed. Water is pump from waterbodies to elevated tanks (called Australian tanks), from there it is delivered into wateries through underground water tubes (Figure 5; Figure 6).

Figure 6. Waterbodies with Australian tanks to deliver rain water to pastures.

The mail activity of the ranch is cattle production for meat, with horse rearing and honey productions as complementary activities. Al the moment of the study Montania had 23,000 heads classified into the following categories: cows, bulls, heifers and calf. Cattle are divided into herds and assigned to modules, each one composed of four pastures and a central watery. To conform herds cattle are classified by age and weight to fit a stocking rate of 0.70 animal unit per hectare (1 animal unite = 450kg), and they rotate through the pastures of their module according to climate and grass condition. The ranch uses artificial insemination at fixed time, so al the born are concentrated during the months from July to September (Figure 7).

Figure 7. Animal biotype at Estancia Montania.

We selected Estancia Montania as study site due to three main reasons. The first one is that Estancia Montania is not neighboring protected wilderness areas, otherwise, results may be affected by source-sink dynamics. The Second one is that Estancia Montania is located in the Central Chaco area, the most intensively developed geographical area. As a matter of fact, the area is easily identified in google earth as a pale spot in the middle of the Paraguayan Chaco. Finally, Estancia Montania produces livestock with high adaptability to local conditions, near carrying capacity of the land. For those reasons, they became a model ranch that other producers look up to.

General Objectives

In order to promote land use practices that enhance biodiversity conservation opportunities in highly productive landscapes, we have to understand the response of local biodiversity to human activities and landscape configuration. The present study aims to collaborate with the clarification of the relationships between the elements that make up the productive landscape and the diversity and composition of birds and mammals' communities. The final intention of this investigation is to elaborate some recommendations that can be valuable for producers as they intend to reach higher sustainable standards, as well as, for the government in order to enhance policies that benefits biodiversity conservation in productive landscapes and connectivity among protected areas.

2. INTRODUCCIÓN

Desarrollo humano y biodiversidad

En todo el mundo, el cambio en la cobertura y el uso de la tierra ha modificado los ecosistemas terrestres, causando la degradación de los recursos hídricos y del suelo (McGill, 2015; Newbold et al., 2015), así como alteraciones en muchos procesos naturales (Stanimirova et al., 2022), como el ciclo del carbono (Ahlström et al., 2015; Baumann, Gasparri, et al., 2017; Pan et al., 2011; Tagesson et al., 2020) y el ciclo del agua (Bosmans et al., 2017; Haddeland et al., 2014). Como consecuencia de la pérdida y degradación de hábitats, la biodiversidad ha sufrido declives moderados a severos debido al crecimiento de la población humana y la intensificación de las modificaciones de la tierra (Beninde et al., 2015; McGill, 2015). Predicciones basadas en las respuestas de la biodiversidad a la agricultura han encontrado que hasta el 30 % de la riqueza de especies puede perderse en los trópicos, especialmente en países con esquemas nacionales de conservación débiles, bajos gastos en conservación y un alto crecimiento agrícola (Kehoe et al., 2017).

Preocupantemente, muchos países de América Latina cumplen con esas condiciones. El continente ha sido un epicentro de conversión de la cobertura terrestre durante varias décadas consecutivas, principalmente para actividades de producción de soja y ganado (Gasparri et al., 2013; Stanimirova et al., 2022). Como consecuencia, el número de especies en las listas de protección local y regional ha aumentado en el continente (Asociación Paraguaya de Mastozoología y Secretaría del Ambiente, 2017; IUCN, 2023; Martinez et al., 2020; Motte et al., 2019). Este escenario ha generado preocupación entre los expertos debido al alto riesgo de extinción de muchas especies raras y endémicas (Brito, 2008; Maciel et al., 2023). De hecho, los países de América Latina han sufrido extinciones locales de especies

debido a la presión humana, como es el caso de los jaguares, ya extintos en Uruguay y El Salvador (Swank y Teer, 1989). Además, 31 especies endémicas de la región neotropical están clasificadas como extintas según la UICN (IUCN, 2023).

Ante este escenario, las prácticas tradicionales de conservación, como la conservación basada en sitios por sí solas, son insuficientes para preservar la biodiversidad y garantizar los servicios ecosistémicos (Visconti et al., 2016). Se necesitan nuevos esfuerzos para garantizar un acceso justo a los alimentos y conservar la biodiversidad, como el establecimiento de políticas que fomenten sistemas productivos más sostenibles. Existen muchas oportunidades para que los gobiernos mejoren la protección de la biodiversidad dentro de sus territorios, considerando la interacción entre la pérdida de hábitats y la expansión agrícola (Dietz y Adger, 2003). Algunas acciones efectivas son la regulación de la expansión agrícola (Chaplin-Kramer et al., 2015), el aumento de la productividad (Acevedo et al., 2018), la reducción del desperdicio de alimentos y cultivos (Guerrero-Pineda et al., 2022), la adopción de mejores prácticas de producción (Kremen y Merenlender, 2018) y educar a los consumidores sobre el impacto de los alimentos en la naturaleza (de Boer y Aiking, 2021), entre otras. Sin embargo, para que estas acciones sean efectivas, se requiere de aceptación cultural y adopción local, por lo que se deben tener en cuenta el entorno socioeconómico y de gobernanza de cada país y su capacidad para implementar estas estrategias (Williams et al., 2021).

Paraguay, país sin salida al mar en el corazón de Sudamérica.

La República de Paraguay es un país sin salida al mar ubicado en el corazón de Sudamérica, con una superficie de 406,752 km2. El país está dividido de norte a sur por el río Paraguay en una región este y otra oeste. La población supera los 7 millones de habitantes y más de 4

millones residen en la ciudad capital y áreas cercanas. El país es bilingüe, con el español y el guaraní como idiomas oficiales, y muchos nombres científicos y comunes de especies tienen sus raíces en este idioma nativo.

Desde el punto de vista biogeográfico, Paraguay es un gran ecotono donde convergen cinco ecorregiones: el Bosque Atlántico, el Cerrado, el Chaco Húmedo, el Chaco Seco y el Pantanal (Dinnerstein, 1995) (Figura 1). De ellas, el Bosque Atlántico y el Cerrado se encuentran dentro de las ecorregiones Globales 200 (Olson y Dinnerstein, 1998), ambas ecorregiones han sido severamente afectadas por la deforestación debido a la agricultura, la ganadería y el comercio de madera. Como ejemplo, entre los años 1973 y 2000, Paraguay perdió dos tercios de su Bosque Atlántico (Huang et al., 2007).

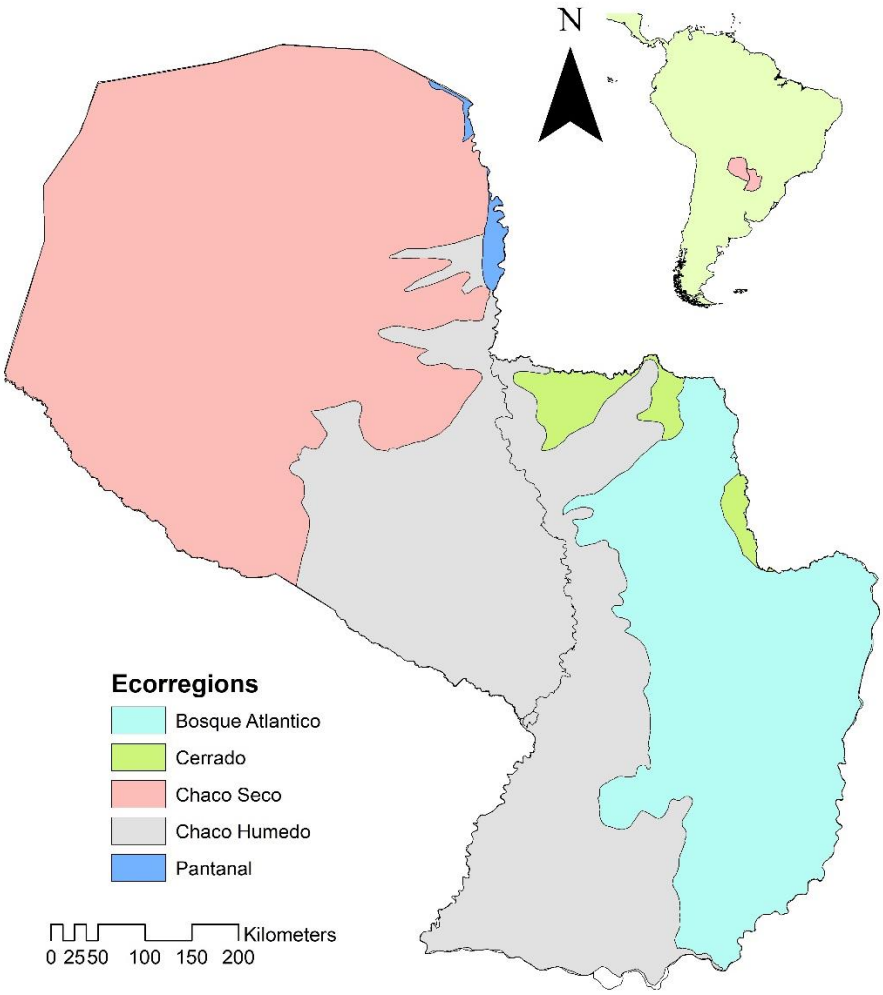

Figure 1. Ecorregiones del Paraguay.

El país alberga una rica biodiversidad, con 181 especies de mamíferos (Asociación Paraguaya de Mastozoología y Secretaría del Ambiente, 2017; De La Sancha et al., 2017), 702 especies de aves (Castillo et al., 2005; Narosky et al., 2022), 191 especies de reptiles (Cabral y Cacciali, 2021; Cacciali et al., 2016; Cacciali y Ortega, 2023; Martinez et al., 2020; Smith et al., 2022) y 87 especies de anfibios (Motte et al., 2019; Weiler et al., 2013). Sin embargo, el conocimiento sobre la distribución de las especies en el país es escaso, existiendo una brecha de información, principalmente en terrenos privados. La literatura moderna sobre vertebrados en el país se basa principalmente en primeras listas de especies para localidades (Cacciali et al., 2016; De La Sancha et al., 2017; Núñez y Weiler, 2015), ampliación de rangos de distribución (Tabilo et al., 2020; Weiler Gustafson y Owen, 2021; Zaracho et al., 2017), nuevos registros para el país (Cabral y Cacciali, 2021; Cacciali y Ortega, 2023; Smith et al., 2022) e incluso nuevas especies para la ciencia (Cabral y Cacciali, 2021; Cacciali et al., 2018).

El Sistema Nacional de Áreas Silvestres Protegidas de Paraguay está compuesto por 88 áreas protegidas, de las cuales 44 son públicas, 31 son privadas y 13 son autárquicas (MADES/PNUD, 2020) (Figura 2). Además, hay 5 reservas de biosfera en el país, 2 declaradas a nivel local y 3 declaradas por la UNESCO. Es importante recordar que las reservas de biosfera no son áreas estrictamente protegidas, esta figura fue establecida por la UNESCO en 1974 como una alternativa para gestionar la convivencia entre el ser humano y la naturaleza de manera adecuada (Reservas de Biosfera, s.f.), y están más destinadas a favorecer el desarrollo sostenible. Por otro lado, no todas las áreas declaradas como protegidas por el gobierno fueron compradas o expropiadas y simplemente se mantuvieron en resoluciones, como resultado, solo el 7% del país está protegido bajo el régimen de Área Silvestre (MADES/PNUD, 2020).

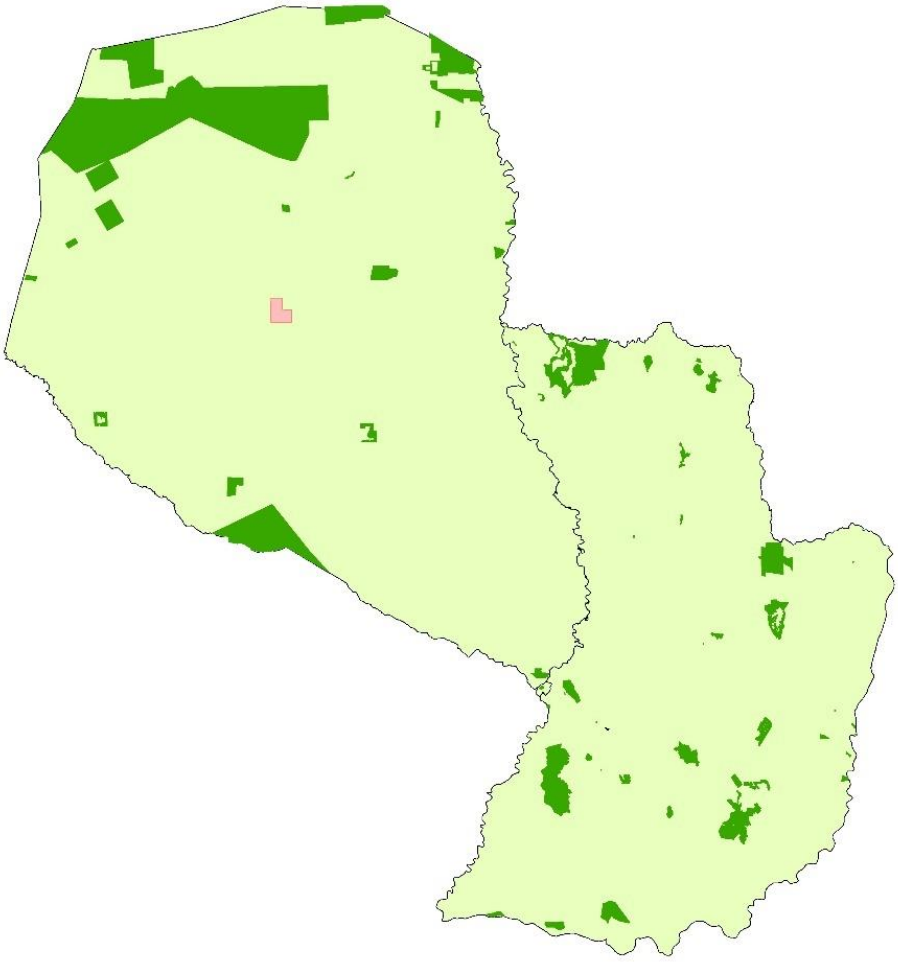

Figure 2. Sistema Nacional de Áreas Silvestres Protegidas de Paraguay (SINASIP). Verde: áreas protegidas; Rosa: Estancia Montania.

La economía paraguaya se basa principalmente en la explotación hidroeléctrica, la agricultura y la ganadería (González et al., 2019). El país cuenta con dos grandes represas hidroeléctricas, Itaipú y Yacyretá, que generan más energía de la que el país consume, exportando el excedente a Brasil y Argentina (Rivarolo et al., 2014). Por otro lado, la producción de soja y ganado ha aumentado significativamente en los últimos años, hasta el punto de que Paraguay se ha convertido en el tercer mayor exportador de soja y el noveno mayor exportador de carne a nivel mundial a pesar de su pequeña superficie (FAO, 2021).

El desarrollo agrícola ha sido y sigue siendo responsable de la alta tasa de transformación de los ecosistemas en favor de las parcelas agrícolas y los campos ganaderos en la región (Fehlenberg et al., 2017; Gasparri y Grau, 2009; Prieto-Torres et al., 2022). En las décadas de 1980 y 1990, Paraguay fue el país con la tasa de deforestación más alta a nivel mundial, con un promedio de 444,810 hectáreas por año (M. C. Hansen y DeFries, 2004). Las pérdidas forestales se concentraron en la región este del país, donde se eliminó el 90% de la cobertura forestal del Bosque Atlántico del Alto Paraná, creando un paisaje altamente fragmentado. Este hecho llevó a que en 2004 el Congreso Nacional sancionara la Ley N.° 2524/04, conocida como "Ley de Deforestación 0", que prohíbe la transformación de áreas forestales para otros usos de la tierra en la región este del país, prohibición que continúa hasta el día de hoy.

Este escenario, sumado al aumento de la demanda internacional de alimentos (Tilman et al., 2011) y el consiguiente aumento de su precio, ha llevado a que el enfoque del desarrollo se vuelque hacia la región oeste del país (Baumann et al., 2017). En esta región, la tasa de cambio en el uso de la tierra ha ido aumentando gradualmente, alcanzando alrededor de 1,000 hectáreas por día, convirtiendo a Paraguay en el país que establece nuevos récords en tasas de deforestación, pero esta vez en la ecorregión del Chaco (Baumann et al., 2017; M. C. Hansen et al., 2013).

La alta tasa de conversión del bosque xerófito del Chaco seco en campos ganaderos implica transformaciones profundas en el hábitat de las especies (de la Sancha et al., 2021). Cómo está afrontando la biodiversidad estas transformaciones es una pregunta poco explorada en el Chaco paraguayo. En este sentido, pocas investigaciones han abordado la respuesta de la fauna a las perturbaciones del hábitat (Areskoug, 2001; Saldívar, 2014; Thompson et al., 2021; Zaldivar et al., 2022). A medida que las fronteras agrícolas continúan expandiéndose en la

región, se necesitan con urgencia más investigaciones que arrojen luz sobre la respuesta de la biodiversidad.

Área de estudio y cobertura forestal

A partir de imágenes de satélite del año 2000 de un área de 294.000 hectáreas que rodea la Estancia Montania, se observó que 157.000 hectáreas correspondían a bosque y 137.000 hectáreas a otros tipos de cobertura de tierra (M. C. C. Hansen et al., 2013) (Figura 3). En este periodo, el bosque espinoso aún era la matriz del paisaje, cubriendo el 53% del área.

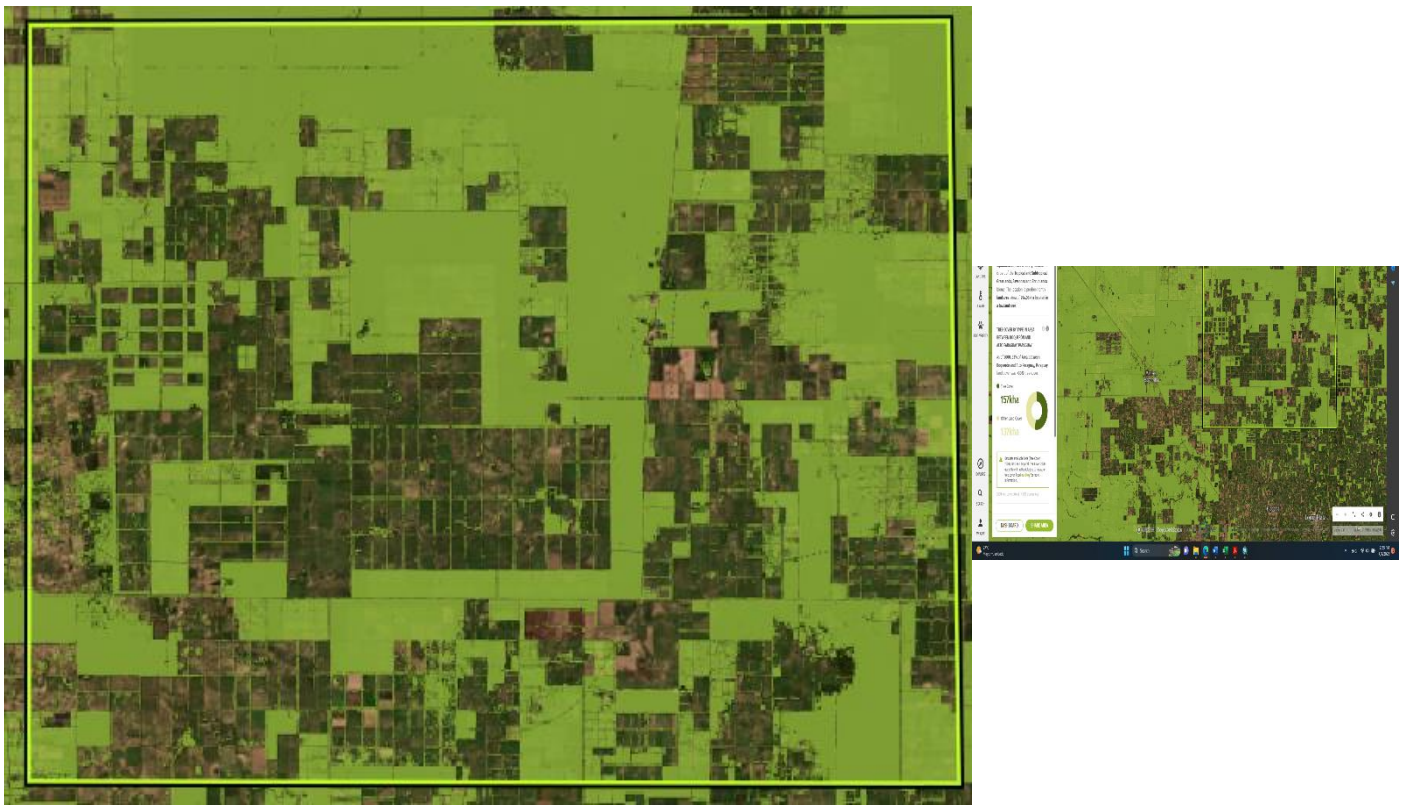

Figure 3. Cobertura forestal del área aledaña a Estancia Montania en el año 2000, Departamentos de Boquerón y Alto Paraguay, Paraguay.

De 2001 a 2022, el área perdió 51.600 hectáreas de cobertura arbórea, lo que representa una disminución del 33% de la cobertura forestal desde 2000 (Global Forest Watch, 2023) (Figura

4). La pérdida de cobertura boscosa, según definen los autores, es la sustitución de cobertura de árboles en la vegetación de más de 5 metros dentro del área seleccionada. Este término no es un sinónimo directo de deforestación y puede deberse a cambios tanto en bosques naturales como plantados, y no necesariamente tiene que ser causado por actividades humanas, como explican los autores en la metodología. Sin embargo, en este caso particular, debido a la forma y configuración de la pérdida de cobertura arbórea, estas pérdidas fueron intencionales para expandir los límites agrícolas. Las principales pérdidas en el área evaluada ocurrieron hasta el año 2014.

Figura 4. Izquierda: Pérdida de cobertura arbórea en el área que rodea Estancia Montania durante los años 2001 a 2022, en los departamentos de Boquerón y Alto Paraguay, Paraguay. Derecha: Proporción de pérdida de cobertura arbórea por año

En el centro del polígono se encuentra Estancia Montania, una finca de 37,098 hectáreas. Los cambios en el uso de la tierra ocurrieron en tres fases, una de 1987 a 1996, otra de 2006 a 2008 y finalmente de 2011 a 2013, cuando la finca alcanza la configuración original. Como resultado, el área total de cobertura arbórea es de 14,658 hectáreas, de las cuales 10,500 hectáreas constituyen la reserva forestal y los 4,158 restantes corresponden a franjas de bosque. La mayoría de las franjas de bosque se encuentran dentro del perímetro cercado de los potreros, por lo que brindan refugio al ganado durante las horas más calurosas en verano y los vientos fríos del invierno. La superficie total de pastos implantados es de 22,440 hectáreas, y se dividen en seis unidades productivas (representadas en el mapa con colores más claros) (Figura 5).

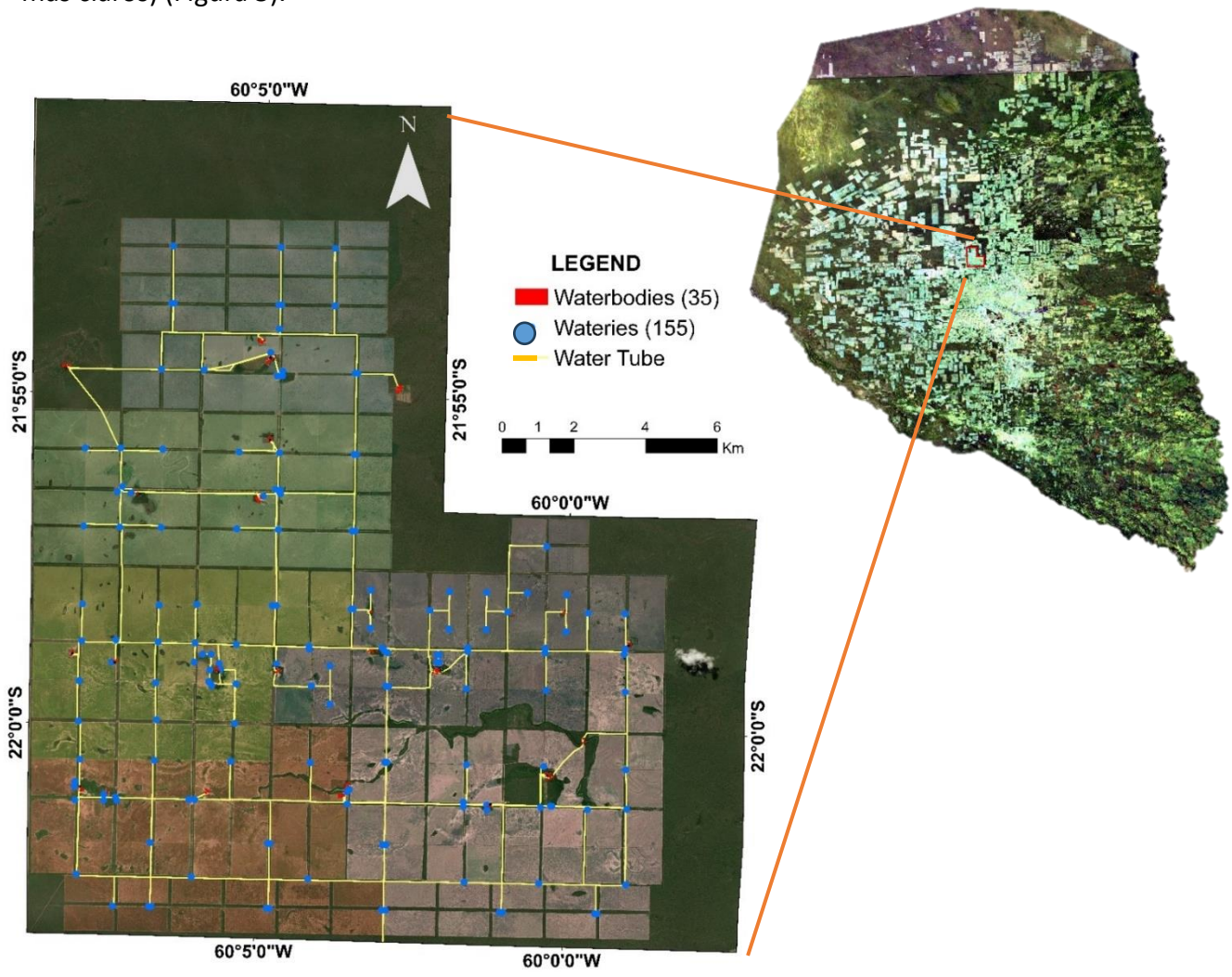

Figure 5. Land configuration of Estancia Montania

La finca tiene treinta y cinco cuerpos de agua, llamados "tajamares". Recogen agua de la lluvia y la almacenan en grandes estanques construidos artificialmente. El agua se bombea desde los cuerpos de agua hasta tanques elevados (llamados tanques australianos) y desde allí se distribuye a través de tuberías subterráneas hasta los abrevaderos (Figura 5; Figura 6).

Figura 6. Cuerpos de agua con tanques australianos para suministrar agua de lluvia a los pastizales.

La actividad principal de la finca es la producción de ganado para carne, con la cría de caballos y la producción de miel como actividades complementarias. En el momento del estudio, Montania tenía 23,000 cabezas de ganado clasificadas en las siguientes categorías: vacas, toros, vaquillonas y terneros. El ganado se divide en rebaños y se asigna a módulos, cada uno compuesto por cuatro pastizales y un abrevadero central. Para conformar los rebaños, el ganado se clasifica por edad y peso para ajustarse a una carga animal de 0.70 unidad animal por hectárea (1 unidad animal = 450 kg), y rota a través de los pastizales de su módulo de acuerdo con el clima y la condición de la hierba. La finca utiliza la inseminación artificial en un

momento específico, por lo que todos los nacimientos se concentran durante los meses de julio a septiembre (Figura 7).

Figura 7. Biotipo animal en Estancia Montania.

Seleccionamos Estancia Montania como sitio de estudio por tres razones principales. La primera es que Estancia Montania no colinda con áreas silvestres protegidas, de lo contrario, los resultados podrían verse afectados por la dinámica de fuente-sumidero. La segunda razón es que Estancia Montania se encuentra en el área central del Chaco, la zona geográfica más intensamente desarrollada. De hecho, el área se puede identificar fácilmente en Google Earth como un área pálida en medio del Chaco paraguayo. Por último, Estancia Montania produce

ganado con alta adaptabilidad a las condiciones locales, cerca de la capacidad de carga de la tierra. Por estas razones, se convirtió en una finca modelo a la que otros productores admiran.

Objetivos generales

Con el fin de promover prácticas de uso de la tierra que mejoren las oportunidades de conservación de la biodiversidad en paisajes altamente productivos, es necesario comprender la respuesta de la biodiversidad local a las actividades humanas y la configuración del paisaje. El presente estudio tiene como objetivo colaborar en la clarificación de las relaciones entre los elementos que componen el paisaje productivo y la diversidad y composición de las comunidades de aves y mamíferos. La intención final de esta investigación es elaborar recomendaciones que puedan ser valiosas tanto para los productores que buscan alcanzar estándares de sostenibilidad más altos, como para el gobierno, con el fin de mejorar las políticas que beneficien la conservación de la biodiversidad en paisajes productivos y la conectividad entre áreas protegidas.

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3. CHAPTER I:

THE INFLUENCE OF HABITAT STRUCTURE ON THE DIVERSITY AND GUILDS OF THE BIRD COMMUNITIES IN LIVESTOCK SYSTEMS OF THE DRY CHACO.

LA INFLUENCIA DE LA ESTRUCTURA DEL HÁBITAT EN LA DIVERSIDAD Y GREMIOS DE LAS COMUNIDADES DE AVES EN SISTEMAS GANADEROS DEL CHACO SECO.

ABSTRACT

Habitat loss and degradation is highlighted as the main cause of biodiversity loss around the globe and humas as being the main promoter of these modifications. Concern has been raised and sustainable production is becoming mandatory. Food production is a major issue in the southern cone economy and is the main activity in Paraguayan economy. In the last decades, Paraguayan Dry Chaco ecoregion suffered an intensive land use change, and land configuration reached a change of matrix in central Chaco, being pastures the main component of landscape. The main concern is how birds are coping with this situation and if landscape configuration influences avifaunal diversity and composition in productive landscapes. We utilized the McKinnon list methodology fixed at 10 species. We searched birds actively by random walking through the different environments, pasture, waterbodies, forest and forest strips, all the birds seen or hearing were recorded.

A total of 445 lists were performed totalizing 4450 records. A total of 225 species were identified with 33 migrant species, 12 bird species endemic of the Dry Chaco and five species listed under conservation concern by IUCN. Waterbodies were the richest environment with 170 species, followed by forest strips with 135 species, forest with 114 species and pasture with 104 bird species. NMDS showed differences between bird communities and trophic niches by habitat type. Waterbodies showed a pull up effect, attracting birds of surrounding environments. Forest presented higher relative abundance of frugivores, nectivores and insectivores' species compared with forest strips and pastures. Forest strips conserved part of the original forest birds' communities and are important as habitat connectors. Pastures presented the lowest richness but showed high turnover of species when compared to forest.

Despite of being an intensive productive cattle ranch, Estancia Montania maintained high bird diversity. However, bird's species responds strongly to changes in forest cover with the loss of forest specialist as tree cover decreases in the landscape. Maintaining waterbodies without cattle, increasing trees numbers in pastures and managing forest strips to improve connectivity are recommended practices to improve long term conservation of birds in productive landscapes.

4. CHAPTER II:

FOREST MATTERS: USE OF WATER RESERVOIRS BY MAMMAL COMMUNITIES IN CATTLE RANCH LANDSCAPES IN THE PARAGUAYANDRY CHACO

LOS BOSQUES IMPORTAN: USO DE LOS RESERVORIOS DE AGUA POR LAS COMUNIDADES DE MAMÍFEROS EN PAISAJES GANADEROS DEL CHACO SECO PARAGUAYO.

COMMENT

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Original Research Article

Forest matters: Use of water reservoirs by mammal communities in cattle ranch landscapes in the Paraguayan Dry Chaco

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ABSTRACT

Cattle ranching has led to a significant decrease in forest cover in the Neotropic. In this study we evaluate how medium- and large-sized mammals cope in these human-modified landscapes in the Paraguayan Dry Chaco, where by state law at least 25% of forest cover must be preserved. Using a camera-trap approach, we studied how the surrounding vegetation matrix and season (dry or rainy) influence the pattern of occurrence and detectability of species around artificial water reservoirs for cattle supply. We registered 26 mammal species, and the responses of 14 different species were modelled. Five species (*Tayassu pecari*, *Leopardus pardalis*, *Pecari tajacu*, *Mazama gouazoubira* and *Myrmecophaga tridactyla*) showed a positive response to forest cover, with *T. pecari* and *L. pardalis* being

ABSTRACT

Cattle ranching has led to a significant decrease in forest cover in the Neotropics. In this study we evaluate how medium- and large-sized mammals cope in these human-modified landscapes in the Paraguayan Dry Chaco, where by state law at least 25% of forest cover must be preserved. Using a camera-trap approach, we studied how the surrounding vegetation matrix and season (dry or rainy) influence the pattern of occurrence and detectability of species around artificial water reservoirs for cattle supply. We registered 26 mammal species, and the responses of 14 different species were modelled. Five species (*Tayassu pecari, Leopardus pardalis, Pecari tajacu, Mazama gouazoubira* and *Myrmecophaga tridactyla*) showed a positive response to forest cover, with *T. pecari* and *L. pardalis* being extremely sensitive to deforestation. Also, forest cover showed a positive effect on the detectability of *Tapirus terrestris* and *Puma concolor*. By contrast, for two generalist canids, *Lycalopex gymnocercus* and *Cerdocyon thous*, and the semiaquatic Hydrochoerus hydrochaeris forest cover negatively influenced species detectability. Cattle ranches have the potential to maintain a substantial part of the original chacoan fauna, with forest cover being a main factor in structuring the mammal assemblages found around water reservoirs. Additionally, in ten species there was a moderate to strong increase in the probability of detection around water reservoirs during the dry season. The conservation of large forest tracts combined with strict compliance with poaching bans are key management strategies for the conservation of mammal diversity in the human-altered landscapes of the Chaco.

INTRODUCTION

Human society is built on biodiversity. However, environmental change from local to global scale to sustain a growing human population has led to a decline in biodiversity, and this trend is likely to continue in the future. (Vitousek et al., 1997; Díaz et al., 2006; Rockstro€m et al., 2009; Cardinale et al., 2012). The loss of biodiversity is usually linked to several interrelated causes such as overhunting, invasive species, population isolation and climate change among others. But changes in land use leading to habitat destruction and degradation exert the most significant impact (Pimm and Raven, 2000; Rockstro€m et al., 2009; Laurance, 2010; Romero-Mun˜oz et al., 2020). Within this context, South America has suffered from a net loss of around 4 million ha of forest between 2000 and 2010, with agriculture and livestock expansion as the main causes of deforestation (FAO, 2016). Owing to the potential loss of biodiversity due to deforestation, the establishment of good management practices in these modified and anthropized landscapes is a priority for biodiversity conservation (Grau et al., 2008; Nún˜ez-Regueiro et al., 2015; Periago et al., 2015; Galetti et al., 2017; Bogoni et al., 2018).

In recent decades, the drivers of deforestation have shifted in the tropics as a consequence of globalized financial markets and an increasing demand for commodities, which has attracted the interest of the private sector (Butler and Laurance, 2008). Nowadays, deforestation is substantially driven by large-scale agriculture and cattle ranching, as opposed to causes related to small-scale farming and local communities (Butler and Laurance, 2008; Laurance, 2010; Caldas et al., 2013). This is, in fact, the case of the Gran Chaco, which is distributed throughout Argentina, Bolivia, and Paraguay, and is the second largest forest in the neotropics after the Amazon rainforest. The Gran Chaco presents a pronounced east west

gradient in precipitation, with the most mesic areas lying closer to the Rio Paraguay in Paraguay and Argentina. Aridity progressively increases to the west, culminating in the driest areas where the Chaco shifts to the Andean foothills. This gradient results in a division of the Chaco into two main climatic subregions: the humid Chaco (from 1000 to 1100 to 1600 mm of rainfall per year) and the dry Chaco (from 400 to 1000e1100 mm of rainfall per year). In the Paraguayan dry Chaco, the annual rate of land transformation is the highest of the region since 2009 (Vallejos et al., 2015), with a loss of around 400 000 ha of forest per year between 2010 and 2014 (Are´valos et al., 2015). Whereas soybean cultivation is the main driver of deforestation in other areas of the dry Chaco, the most significant driver in Paraguay is large-scale cattle ranching (Caldas et al., 2013), causing the greatest mean size of deforested patches in the region (Vallejos et al., 2015). In an effort to conserve the Chaco Forest in Paraguay and to preserve its biodiversity, landowners in the Chaco (with at least 2000 ha) are obliged by law to preserve at least 25% of their properties covered with natural forests (Article 42 of Forestry Law 422/73).

Mammals, especially medium- and large-sized species (i.e. adult body mass >1 kg), are usually strongly affected by habitat destruction and degradation in all of the neotropics (Periago et al., 2015; Galetti et al., 2017; Bogoni et al., 2018). The diversity of these types of mammals in the Gran Chaco competes with the tropical forests of South America, showing high level of endemic and vulnerable mammal species (Redford et al., 1990; Mares, 1992). Medium- and large-sized mammals are key components for the adequate functioning of ecosystem processes, and carry out unique ecological roles in the Gran Chaco. This involves mainly regulating plant recruitment and chacoan biodiversity through long-distance seed dispersion, seedling and seed consumption, and controlling the populations of granivore and herbivorous species (Silman et al., 2003; Beck, 2005; Weckel et al., 2006; Keuroghlian and Eaton, 2009;

Jorge et al., 2013; Periago et al., 2015; Galetti et al., 2015; Sarasola et al., 2016). Additionally, hunting greatly interacts with land conversion, as increased accessibility to the previous so-called impenetrable chacoan forests goes hand in hand with the increased risk of the extinction of native species (Peres, 2001; Altrichter and Boaglio, 2004; Altrichter, 2006; Periago et al., 2015; Benítez-Lo´pez et al., 2017). Subsistence hunting using traditional methods by indigenous communities is regulated by law in some natural areas (Hill et al., 1997; Hill and Padwe, 2000), but prohibited and un-regulated commercial and sport poaching is a common activity in the country which threatens the conservation status of several mammal species (Jacquet et al., 2008; Weiler and Nuñez, 2012; Asociacio´n Paraguaya de Mastozoología and Secretaría del Ambiente, 2017).

Deforestation, linked to the expansion of cattle ranching, and increased illegal hunting are not the only factors that can potentially affect mammal diversity in the dry Chaco. Due to the seasonal dry climate, different systems for harvesting rainwater have been designed to secure water supplies for the livestock along the dry Chaco. These systems range from being very primitive and inexpensive to very complex and highly sophisticated (Magliano et al., 2015). As a result, permanent bodies of water are increasingly available throughout the landscape. Subsequently, some key species, like the semi-aquatic capybara Hydrochoerus hydrochaeris, are expanding their range to the west, migrating from humid areas to the previously uninhabitable Paraguay dry Chaco (Campos-Krauer and Wisely, 2011). Additionally, permanent artificial bodies of water provide a critical resource for the native fauna in seasonally dry climates where natural water bodies are scarce (Valeix et al., 2008; Astete et al., 2017; Dias et al., 2019).

In this study, we used a camera trapping to assess how medium- and large-sized mammals (adult body mass >1 kg, Nuñez-Regueiro et al., 2015; Bogoni et al., 2018) cope in these human-modified landscapes dominated by large cattle ranches in the Paraguayan dry Chaco (mean size of deforested patches is around 3500 ha, Vallejos et al., 2015). To this end, we established the following objectives: (1) to analyze how the surrounding vegetation matrix influences the use of water reservoirs by medium- and large-sized mammals (our hypothesis is that the sites with the greatest forest cover around water reservoirs will show mammal assemblages that most closely resemble the original community, with the presence of generalist and forest specialist species); and (2) to investigate the seasonal use of water reservoirs during the dry and rainy season. As water availability is a limiting resource in these seasonally dry environments, we assume there will be a more intense use of water reservoirs by mammals during the dry season, which would equate to an increase in the probability of detecting mammals.

MATERIAL AND METHODS

Study area

The study area was located in Estancia Montania (21°57′48′′ S, 60° 04′19′′ W), Department of Boquerón, in the dry Chaco ecoregion of west Paraguay. Estancia Montania is a cattle ranch extending over a total of 37 000 ha and it raised approximately of 23 000 heads of cattle of the Brangus breed during the study period. Extensive cattle ranches like Estancia Montania are common in the Paraguayan dry Chaco. Forest clearing began in 1987, and the extension of pastures gradually

increased until 2014, when deforestation in the ranch ceased and the current landscape configuration was reached. A total of 10 500 ha (28% of the property) currently remains uncleared, as stipulated by Article 42 of the Forestry Law 422/73, and is covered by continuous primary dry forest. *Aspidosperma triternatum*, *Bulnesia sarmientoi*, *Ceiba chodatii*, *Prosopis kuntzei* and *Schinopsis balansae* are the dominant tree species in the primary dry forests, and the palm *Copernicia alba* is the most dominant species growing in seasonally flooded soils. 3443 ha (9%) is also covered by forest vegetation distributed in 100-m-wide strips with a dirt road running along the middle. Vegetation strips act as windbreakers surrounding the 100 ha patches of managed pastures. 22 360 ha (60%) are covered by pastures, organized in units of 100 ha patches (1x1 km) for the purpose of managing the cattle. Pastures are dominated by the introduced guinea grass *Panicum maximum* cv. Gatton (Poaceae). Initially (between 1987 and 2007) all trees and shrubs were cut down during land clearing, although a sparse cover of recruiting

Prosopis nigra and *P. alba* trees still remain, providing the cattle with shade and forage. The most recent clearings, between 2008 and 2014, left a density of 30% of the remaining trees per ha (Resolución INFONA, 1915/2013).

The study area is located at 150 m asl., and the region is a large alluvial plain with Haplic Luvisol - Eutrical Cambisol as the most abundant soils (FAO/UNESCO 1990). The annual precipitation recorded at the ranch was 905 mm in 2015 and 1001 mm in 2016. There is a high level of seasonal variation, including a rainy season from October to April (mean 813 mm) and a dry season from May to September (mean 140 mm). The

mean annual temperature ranges from 18 to 24 °C in winter (the dry season) and from 25 to 29° in summer (the rainy season) (DGEEC, 2016).

Hunting is an activity that is controlled by the Paraguayan Wildlife Law (Law 96/92), although permits are not granted for sport or subsistence hunting. However, poaching is a common problem in the country (Jacquet et al., 2008; Weiler and Nuñez, 2012; Asociación Paraguaya de Mastozoología and Secretaría del Ambiente, 2017). Strict compliance with the law is overseen by the ranch manager and owners and, as a result, the impact of hunting in Estancia Montania is quite low.

Data collection

We selected 12 of the 32 water reservoirs artificially established in Estancia Montania. To maximize the range of the predictive variable (Gotelli and Ellison, 2012), i.e. the forest cover around water reservoirs, we selected the only two water reservoirs surrounded by primary continuous forest whereas the other 10 sites were randomly chosen. Water reservoirs comprised a rectangular pond (80 m long, 40 m wide, and 2e6 m deep) and a circular tank. The circular tanks were elevated 4e14 m above the ground surface. Runoff water was captured by the rectangular pond and water was pumped into the circular tank where it was stored and delivered to livestock wells through gravity. The livestock did not have direct access to these water reservoirs and the distance between them was 8.3 ± 3.9 km (mean ± s.d.).

For each reservoir, a camera trap (Bushnell Trophy/Velleman) was located in a wildlife trail placed on the path leading toward the reservoir at approximately 50 cm above the ground, and no bait was used. Stations were examined monthly between July 2015 and July 2016, and the memory cards and batteries were changed when

necessary. The camera traps were programmed to operate for 24 h day^{-1}, taking three pictures with a time interval of 1 s, followed by a 10-s-long video. The sampling effort totaled 2877 trap-nights, as camera/batterie malfunctioning and full memory cards after windy periods reduced the maximum potential sampling effort.

Percentage of forest cover was measured in a 1 km-buffer area centered in each camera trap using the Arc Gis 10.5. software. Forest cover was 28.5% ± 27.4 (mean ± s.d.) and ranged from 10 to 12% of the total cover near the water reservoirs surrounded by pastures, and up to 98% near water reservoirs surrounded by primary dry forests (Fig. 1). There was a sig- nificant inverse correlation between forest and pasture covers (r ¼ —0.998, Pearson coefficient, Fig. S1).

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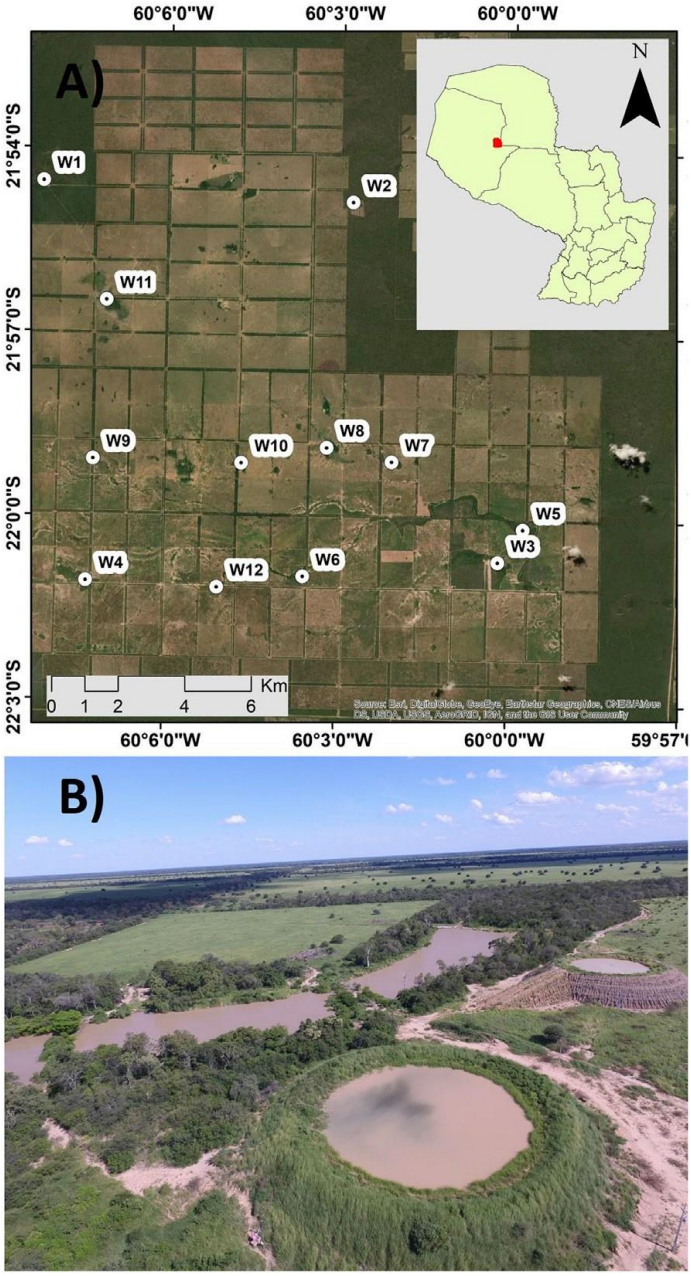

Fig. 1. A) Aerial photograph of the Estancia Montania cattle ranch. Locations of the sampled water reservoirs are indicated by code sites. Inset shows cattle ranch location in Paraguay. B) Water reservoir system at the study area. Runoff water is collected by rectangular ponds and pumped into circular tanks that are elevated above the ground surface. Cattle pastures are depicted at the bottom of the image. The forest cover surrounding each water reservoir varies between sites.

Statistical analysis

We merged the camera-trapping data using 5-day intervals (84 occasions). We used an occupancy modelling approach, as described by Mackenzie et al. (2006), to estimate

individual species occupancy (ψ) and detection probabilities (p). For oc- cupancy modeling, we considered the species that appeared at least ten times (14 presences were the minimum for *Leopardus pardalis*) in their detection record. Thus, we were able to evaluate a total of 14 species. For each species, a set of eight candidate models (Table S1) were selected using the following *a priori* hypotheses: 1) forest cover will influence the probability of occupancy at the water reservoirs; 2) forest cover will influence the probability of detection; and 3) season (rainy or dry season) will influence the probability of detection. We fitted the detection histories and the matrix/season covariates into a single-season occupancy model, since the occupancy status of the mammal species was considered to be constant throughout the study year (Mackenzie et al., 2006). The candidate models were assessed based on the Akaike Information Criterion corrected for a small sample size (AIC_c) and Akaike weights (u_i). Occupancy and detection probabilities were calculated using model averaging by multiplying each parameter estimate by the AIC weight of each of the top models with delta AICc <2 units (AIC_c weights 1). Occupancy modelling was performed with the PRESENCE 12.24 software (Hines, 2006). Overdispersion parameter ($\hat{c}$) was estimated by bootstrap resampling (1000 times), and were significant overdispersion was found (Table S2), the models were adjusted by the Quasi-AIC_c (MacKenzie and Bailey, 2004). *Puma concolor* was modelled using Royle and Nichols (2003) heterogeneous detection probabilities, due to the absence of convergence in parameter estimation under homogeneous detection assumptions (Mackenzie et al., 2006).

We also used a Principal Coordinate Analysis (PCoA) to visualize the differences in the use of water reservoirs by mammal communities in relation to the surrounding matrix

(pastures or primary forests). The intensity of the use at each site by each mammal species was calculated as the proportion of weeks with detections in relation to the total number of weeks. Data was transformed using the Hellinger transformation. PCoA was analyzed using the *cmd scale* function and Bray-Curtis as dissimilarity distance (Borcard et al., 2018) and forest cover (%) was projected using the *ordisurf* function. This analysis was performed with the *vegan* library (Oksanen et al., 2018) under the R environment (R Development Core Team, 2018).

RESULTS

We recorded 26 species mammals of medium to large size belonging to 13 families (Table 1). 22 and 24 species were detected in the dry and the rainy season, respectively. Species that appeared exclusively in the dry or rainy season were species recorded only with 1 or 2 presences. In total, 22 817 photographs showed positive sightings of native fauna that were subsequently identified at the species level. *Hydrochoerus hydrochaeris* (capybara) was the most prominent animal around the water reservoirs, appearing in 74.1% of the pictures, followed by *Pecari tayacu* (collared peccary, 5.9%), *Tayassu pecari* (white- lipped peccary, 3.7%), *Mazama gouazoubira,* (gray brocket, 3.2%) and *Tapirus terrestris* (tapir, 3.2%; Table 1).

Table 1. List of medium- and large-sized mammal species potentially encountered in the dry Chaco forests. National and global conservation status of the species is shown based on UICN criteria.

Family	Species (Species code)	Nº of sites with presences (nº of pictures)	MADES Res. 632/2017 [a]	UICN [b]
Dasypodidae				
	Dasypus novemcinctus	1 (3)	LC	LC
Chlamyphoridae				
	Cabassous chacoensis	0	LC	NT
	Calyptophractus retusus	0	LC	DD
	Chaetophractus vellerosus	1 (1)	LC	LC
	Chaetophractus villosus	3 (14)	LC	LC
	Euphractus sexcinctus	1 (9)	LC	LC
	Priodontes maximus	1 (1)	EN	VU
	Tolypeutes matacus	8 (172)	LC	NT
Myrmecophagidae				
	Myrmecophaga tridactyla	5 (41)	VU	VU
	Tamandua tetradactyla	3 (10)	LC	LC
Tapiridae				
	Tapirus terrestres	8 (722)	VU	VU
Cervidae				
	Mazama gouazoubira	9 (728)	LC	LC
	Mazama americana	0	LC	DD
Tayassuidae				
	Tayassu pecari	4 (845)	VU	VU
	Pecari tajacu	7 (1339)	LC	LC
	Parachoerus wagneri	2 (178)	EN	EN
Canidae				
	Cerdocyon thous	12 (501)	LC	LC
	Chrysocyon brachyurus	0	VU	NT
	Lycalopex gymnocercus	11 (200)	LC	LC
Felidae				
	Leopardus pardalis	3 (43)	NT	LC
	Leopardus geoffroyi	10 (434)	LC	LC
	Puma yaguaroundi	1 (4)	LC	LC
	Puma concolor	9 (85)	LC	LC
	Panthera onca	3 (18)	CR	NT
Mephitidae				
	Conepatus chinga	10 (123)	LC	LC
Mustelidae				
	Eira barbara	1 (3)	LC	LC
	Lontra longicaudis	0	LC	NT
	Galictis cuja (GalCuj)	3 (7)	LC	LC
Procyonidae				
	Procyon cancrivorus (ProCan)	12 (417)	LC	LC
	Nasua nasua	0	LC	LC
Hydrochaeridae				

	Hydrochoerus hydrochaeris (HydHyd)	12 (16908)	LC	LC
Caviidae				
	Dolichotis salinicola	0	LC	LC
Myocastoridae				
	Myocastor coypus	0	LC	LC
Leporidae				
	Sylvilagus brasiliensis (SylBra)	3 (11)	NE	LC

[a] Asociación Paraguaya de Mastozoología y Secretaría del Ambiente (2017)
[b] IUCN (2019).

In relation to occupancy probability, *T. pecari* and *Leopardus pardalis* (ocelot) were the species with the strongest response to forest cover (Fig 2ab, Table S1). *Tayassu pecari* showed an extremely low probability of occupancy when forest cover was below 30%, and *L. pardalis* only showed high occupancy probabilities when forest cover was high (beyond 70%). Additionally, forest cover had a strong positive effect on the detectability of *T. pecari* (Fig. 2a). Forest cover also showed a positive effect, although weaker, on the occupancy probability of *P. tajacu*, *M*. *gouazoubira* and *Myrmecophaga tridactyla* (giant anteater) (Fig 2cde, Table S1). Forest cover did not show a clear effect on the occupancy probability around the water reservoirs with respect to *Tapirus terrestris*, but had a very strong and positive effect on its detection probability (Fig. 2f, Table S1). *Puma concolor* (puma) showed a high probability of occupancy that was independent of forest cover, but also showed a positive increase in detection probability in relation to forest cover (Fig. 2g, Table S1). Forest cover did not show any clear effect on the occupancy and detection probabilities of *Tolypeutes matacus* (southern three-banded armadillo), *Leopardus geoffroyi* (Geoffroy's cat), *Conepatus chinga* (Molina's hog-nosed skunk) and *Procyon cancrivorus* (crab-eating raccoon) (Fig 2hijm, Table S1). Lastly, *H. hydrochaeris, Cerdocyon thous* (crab-eating

fox) and *Lycalopex gymnocercus* (pampas fox) showed occupancy probabilities approaching 1.0, being independent of forest cover, but showed higher detection probabilities when the percentage of forest cover was low (Fig 2kln, Table S1).

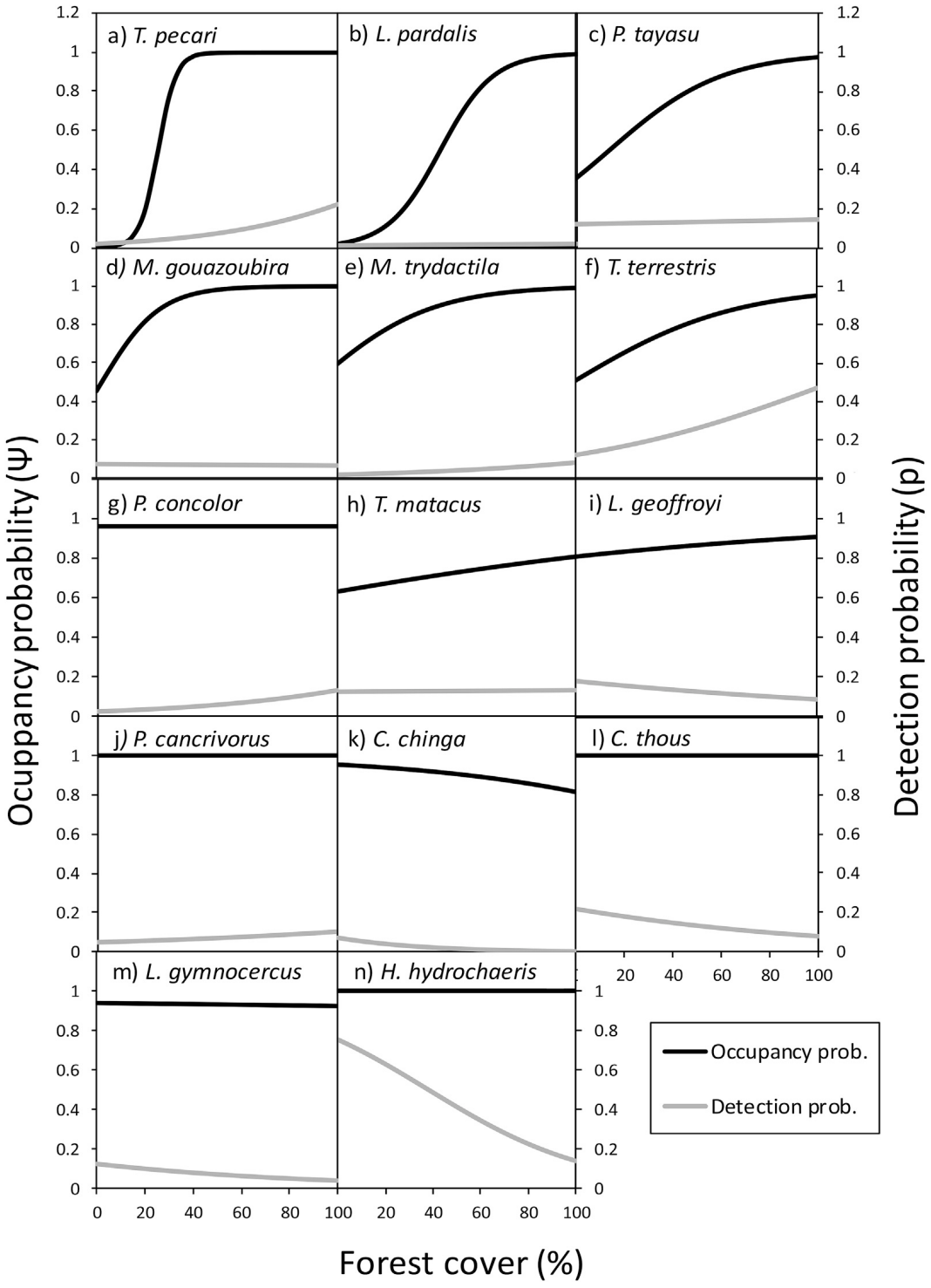

Fig. 2. Occupancy (black line) and detection (gray line) probabilities of the selected mammal species in relation to forest cover (%).

Seven species, *Procyon cancrivorus*, *M. gouazoubira*, *Leopardus geoffroyi*, *C. thous*, *Conepatus chinga*, *L. pardalis* and *T. pecari*, exhibited a higher detection probability during the dry season rather than the rainy season (u_i > 0.80, Fig. 3, Table S1). Additionally, the results obtained for three species, *H. hydrochaeris*, *P. tajacu* and *P. concolor*, weakly supported the hypothesis that detection is higher during the dry season (u_i > 0.50, Fig. 3, Table S1). For the remaining species, the detection probabilities were similar throughout the year (Fig. 3, Table S1).

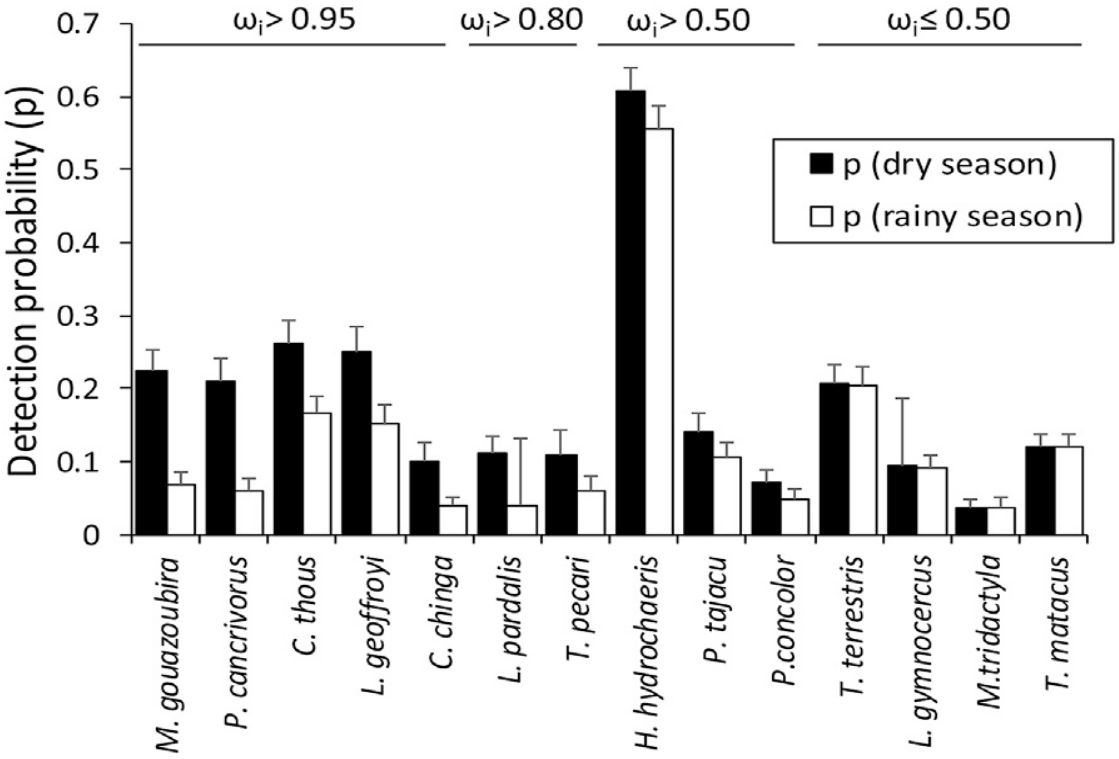

Fig. 3. Detection probabilities (±SE) of the selected mammal species during the dry (black) bars) and wet seasons (black bars). Species are ordered from left to right according to stronger evidence of higher detection probabilities during the dry season. Combined weighs (ui) of the models where detection probability is affected by season are shown.

The PCoA analysis showed the dissimilarities between sites in the two first axes of ordination (which explained 63.9 percent of the variation, Fig. 4). The sites with water reservoirs surrounded by high forest cover showed high-intensity use by *T. terrestris*, *T. pecari*, *P. tajacu*, *L. pardalis*, *M. gouazoubira, P. concolor*, *Myrmecophaga tridactyla*

and *Tamandua tetradactyla*. In contrast, the sites with water reservoirs surrounded by pastures and low forest cover were characterized by high-intensity use by *Hydrochoerus hydrochaeris*, *Cerdocyon thous* and *Lycalopex gymnocercus*.

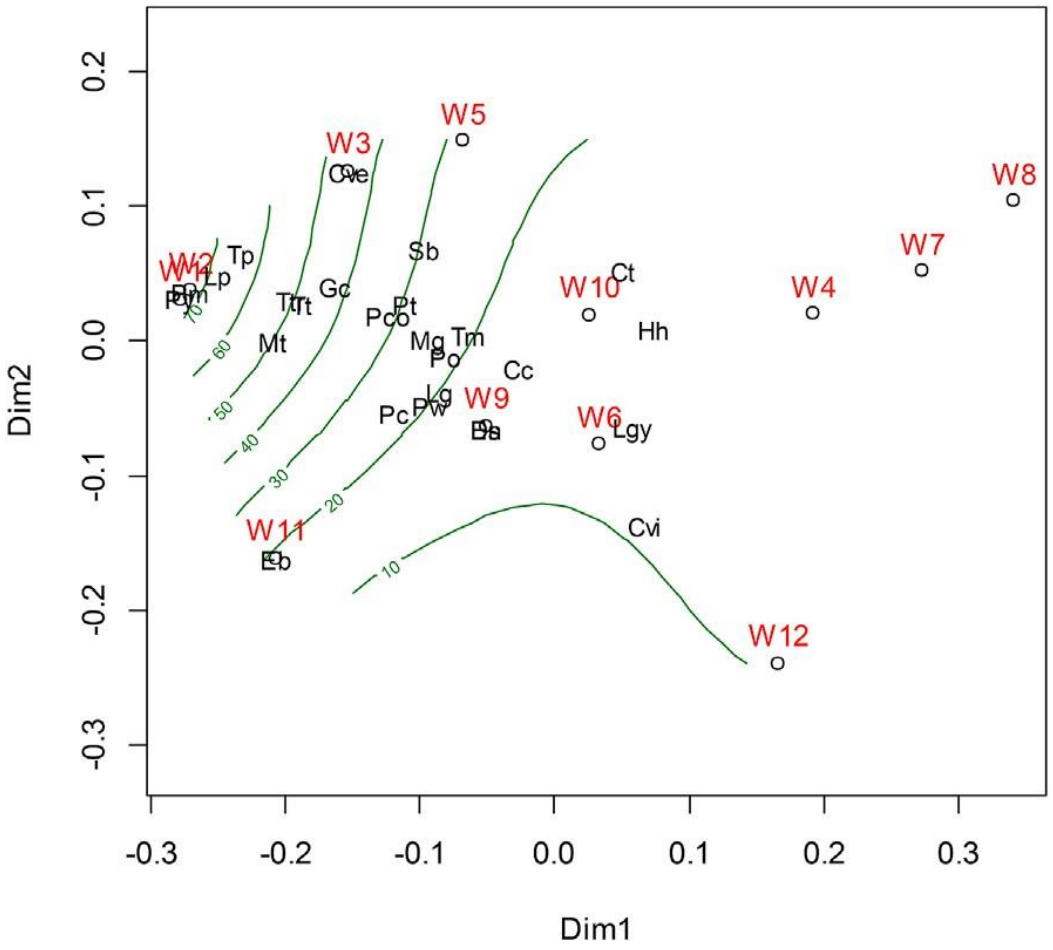

Fig. 4. Principal Coordinate Analysis (PCoA) showing differences in the use of water reservoirs by mammal communities in relation to the surrounding forest matrix. Sites were consecutively numbered from the highest forest cover (W1) to the lowest forest cover (W12). Green lines show variation in forest cover (%) in the ordination space. Species codes are: Cc: *C. chinga*, Ct: *C. thous*, Cve: *C. vellerosus*, Cvi: *C. villosus*, Dn*: D. novemcinctus*, Eb: *E. barbara*, Es: *E. sexcintus*, Gc: *G. cuja*, Hh: *H. hydrochaeris*, Lg: *L. geoffroyi*, Lgy: *L. gymnocercus*, Lp: *L. pardalis*, Mg: *M. gouazoubira*, Mt: *M. tridactyla*, Pc: *P. cancrivorus*, Pco: *P. concolor*, Pm: *P. maximus*, Po: *P. onca*, Pt: *P. tajacu*, Pw: *P. wagneri*, Py: *P. yaguaroundi*, Sb: *S. brasiliensis*, Tm: *T. matacus*, Tp: *T. pecari*, Tt: *T. terrestris*; Ttr: *T. tetradactyla*. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

DISCUSSION

Although extensive land-use change and deforestation is a current problem, our study shows that cattle ranches have the potential to maintain a substantial part of mammal diversity. Around 75e80% of the medium- and large-sized mammals previously cited as being present in our study area were in fact detected (Table 1). Of the potential eight non-detected species (Table 1), two of them, the coati (*Nasua nasua*) and the chacoan mara (*Dolichotis salinicola*), were detected during later camera trap studies in Estancia Montania (data not shown). The semiaquatic species *Lontra longicaudis* and *Myocastor coypus* were not detected, most probably due to their strong preference for water bodies. Also, armadillos *Cabassous chacoensis* and *Calyptophractus retusus*, of which little is known, are mainly fossorial species, and are likely to have an extremely low detectability using the camera-trap approach. Furthermore, our study site is located in the outer limits of the distribution range of the maned wolf *Chrysocyon brachyurus*, although the expansion of its range in Brazil, associated with deforestation and the conversion to grasslands, has recently been reported (Queirolo et al., 2011). *M. gouazoubira*, on the other hand, was commonly found and easily detected. However, the related red brocket deer *M. americana* was not detected. Some studies have suggested that *M. gouazoubira* and *M. americana* generally inhabit separate areas; *M. americana* tends to choose moister habitats in the Chaco (Rumiz, 2002; Rivero et al., 2005) and are rarely detected in drier sites (Rumiz, 2002; Deem et al., 2004). We were able to detect a relatively complete mammal assemblage in these human-modified landscapes. Also, all the species listed in the three categories of higher threat ("Critical", "Endangered" and "Vulnerable")

at the global (UICN, 2019) and regional levels (Asociación Paraguaya de Mastozoología and Secretaría del Ambiente, 2017) were present; some of which, such as the "Vulnerable" species *Tapirus terretris* and *Tajassu peccary,* had a relatively high probability of detection. Very few studies have addressed the conservation potential of large farmlands in the Chaco, despite their increase over the past few decades. The mammal communities found in agricultural fields with a landscape configuration similar to that of the Argentinian Chaco (Nuñez-Regueiro et al., 2015) are known to be more impoverished than in our study area, especially the threatened species (Nuñez-Regueiro et al., 2015). There could be two possible reasons that explain the rich diversity of mammals found in Estancia Montania. First, extensive deforestation in the Paraguayan dry Chaco started later than in other chacoan regions, although it has accelerated dramatically in the last two decades (Caldas et al., 2013; Arévalos et al., 2015; Vallejos et al., 2015). Thus, although these species have initially survived habitat change, they could eventually become extirpated without any further habitat modification, a process known as extinction debt (Tilman et al., 1994; Kuussaari et al., 2009). Therefore, it is imperative to continue monitoring these sites; however, the presence of several females with offspring registered by the camera-traps (data not shown) supports the potential of cattle ranches to conserve biodiversity in the long term. The second explanation, and most likely the most critical, is that the pressure associated with hunting is low within our study site. Although these water reservoirs are usually the places preferred by illegal poachers to stalk their prey, we only detected one poacher in one single day throughout the entire study period (data not shown). Hunting is explicitly and strictly prohibited for all workers in Estancia Montania, and the single poacher detected was an intruder

unassociated with the cattle ranch. Although hunting pressure usually interacts synergistically with habitat conversion and fragmentation, this activity is undoubtedly one of the main drivers of defaunation in neotropical forests (Altrichter et al., 2012; Laurance et al., 2012; Periago et al., 2015; Galetti et al., 2017; Bogoni et al., 2018; Romero-Muñoz et al., 2020). Moreover, strict compliance with hunting bans are likely to be an important issue related to the management of the conservation of mammal diversity in human-altered landscapes.

Of the species analyzed, 71% showed a moderate to strong increase in probability detection around water reservoirs during the dry season. Since many neotropical mammals have a stronger preference toward habitats closer to water sources, due to the availability of water itself and the associated prey (Goulart et al., 2009; Astete et al., 2017; Regolin et al., 2017; Dias et al., 2019), it is not surprising there was a higher frequency of use around artificial water reservoirs during the dry season. Natural bodies of standing water are abundant during the rainy season but become greatly reduced or disappear entirely during the dry season (Eidt, 1968; Magliano et al., 2005). Therefore, permanent man-made water reservoirs are likely to be essential resources for mammal communities in the cattle ranches located within the dry Chaco. In fact, in other extreme habitats like the Caatinga of northwestern Brazil, artificial water sources are managed infrastructures in protected areas that explain the spatial distribution of herbivore/frugivore species, such as *M. gouazoubira* and *P. tajacu*, and the large carnivores that prey on them like *P. concolor* (Astete et al., 2017).

Although the time of year influenced the probability detection of most of our species, forest cover was a critical factor in determining the composition of mammal

communities detected around water reservoirs. The species most affected by the lack of forest cover were the white-lipped peccary, *Tayassu pecari*, and the ocelot *Leopardus pardalis*. In the case of *T. peccary*, this species is considered vital for maintaining ecosystem processes, and is important for seed predation and dispersion, plant demography and diversity, as well as being prey for jaguars and pumas (Silman et al., 2003; Beck, 2005; Keuroghlian and Eaton, 2009; Altrichter et al., 2012), and have been proposed as surrogate to monitor ecosystem functioning (Jorge et al., 2013). Forest lost and hunting pose the most significant threat to this species, and, as in other biomes, are driving the

steep decline in the number of white-lipped peccary in the Chaco region (Altrichter and Boaglio, 2004; Sowls, 2013; Núñez-Regueiro et al., 2015; Reyna-Hurtado et al., 2016). In our site, the low hunting pressure suggests that forest loss can be enough to cause an irreversible decline in the white-lipped peccary populations if connectivity for this species becomes seriously compromised in the absence of adequate forest corridors between suitable patches. White-lipped peccary consumes a large amount of food consisting mainly of fruits and large seeds of tree and palm species (Beck, 2005) and so it requires large and ecologically intact forest to maintain viable populations (Altrichter et al., 2012). Additionally, *T. pecari* was more commonly detected around water reservoirs during the dry season than during the rainy season. Water is a limiting factor responsible for the high level of mortality observed during the dry season which affects herd size (Reyna-Hurtado et al., 2009, 2016). But again, although artificial water reservoirs provide a key resource for this species, the lack of enough forest cover precluded its use in most of our study sites during the dry season. The other species most affected by the loss of forest cover was the ocelot

Leopardus pardalis, which is classified within the "Least Concern" category by the IUCN. Its populations show a range-wide decrease (Paviolo et al., 2015), and in Paraguay is now considered as a "Near Threatened" species (Asociación Paraguaya de Mastozoología and Secretaría del Ambiente, 2017). The importance of forest cover for this species is well established (Har- veson et al., 2005; Lyra-Jorge et al., 2010; Regolin et al., 2017; Paolino et al., 2018), but its sensitivity to the loss of forest covervaries among studies. Although some authors describe the ocelot as a species tolerant of intermediate-cover sites (Goulart et al., 2009), our results are in accordance with the reports that stress the ocelot is extremely sensitive and only occupies densely forested areas (Harveson et al., 2004; Regolin et al., 2017; Cruz et al., 2019). Strong preference of ocelot for dense vegetation has been related with prey availability (Wang, 2002; Cruz et al., 2019), avoidance of large predators in open areas (Harvenson et al., 2004) and susceptibility to human activity (Cruz et al., 2019). Other mammals with a strong preference toward habitats with high forest cover were *Pecari tajacu*, *Mazama gouazoubira*, *Tapirus terrestris* and *Myrmecophaga tri-dactyla*. The higher occupation of forested water sources by anteaters is consistent with the results found in wetlands in Argentina (Di Blanco et al., 2017) and differ from the results obtained for Brazil's Pantanal (Mour˜ao and Medri, 2007). Water sources also drove habitat selection for *P. tajacu*, *M. gouazoubira* and *T. terrestris* (Norris, 2014; Astete et al., 2017; Ferreguetti et al., 2017) and *M. gouazubira* was the species with the most significant difference regarding detectability between seasons. This is most likely related to being less dependent on water sources during the wet season and more dependent during the dry season, since importance of distance to water as a predictor variable of occupancy has been only observed in dry envi-

ronments (Ferreguetti et al., 2015; Astete et al., 2017; Rodrigues et al., 2017). However, these species showed occupancy probabilities of around 0.4e0.6 when the forest cover was between 15 and 20%. This suggests *M. gouazubira* is more tolerant to deforestation than *T. pecari* and *L. pardalis*, or at least shows the potential of using forest strips for a few kilometers encouraging the animals to use the water reservoirs (Nuñez-Regueiro et al., 2015).

Furthermore, the mammal assemblages around the water reservoirs surrounded by a higher cover of cattle pastures were dominated by two canid species, the Pampas fox *Lycalopex gymnocercus* and the crab-eating fox *Cerdocyon thous*, as well as the semiaquatic capybara *Hydrochoerus hydrochaeris* (Fig. 4). Although the forest cover did not affect the occupancy probability of these species, it did have a negative effect on the detection probability, findings which indicate a high-intensity use of areas dominated by open pastures. Both canids are generalist species with similar diets, and are tolerant of anthropogenic impact (Di Bitteti et al. 2009; Dias and Bocchiglieri, 2016; Bossi et al., 2019). In the case of *L. gymnocercus*, this species is usually described as inhabiting grasslands, but can also be found in wooded savannas, deserts, and open forests. *C. thous*, on the other hand, has been described as a habitat generalist. However, both species are known to have a strong preference toward grazed areas occupied by cattle, which is likely related to predator avoidance and prey consumption (Di Bitteti et al. 2009; Dias et al., 2019). The capybara, *Hydrochoerus hydrochaeris*, was the most commonly detected species in our study area, and in all sites the presence of capybara herds was recorded. Capybara is a semi-aquatic species that requires permanent bodies of standing water, and their populations over the past decades have been continuously expanding westwards toward the

Paraguayan dry Chaco due to deforestation and land conversion. Also, the increase in the number of cattle ranches has been the primary driver for the expansion of its range (Campos-Krauer and Wisely, 2011). The detection probability of capybara was greater in areas surrounded by the high cover of pastures, since this species is an efficient grazing herbivore that preferably feed on grasses (Quintana, 2003; Desbiez et al., 2011). However, increasing populations of *H. hydrochaeris* has led to some negative effects. *H. hydrochaeris* compete with livestock for pastures (Quintana, 2003; Desbiez et al., 2011) and during the dry season, the scarcity of grasses can alter its habitat use by intensifying its movement, which in turn reduces selectivity and increases the trampling of and the damage caused to tree seedlings (Fleury et al., 2015). In addition, *H. hydrochaeris* has the potential to infect cattle, wildlife and humans with pathogens and parasites (Labruna et al., 2004; Herrera et al., 2005). On the other hand, *H. hydrochaeris* is one of the main types of prey for jaguars and pumas, and their abundance helps to reduce conflicts between big cats and cattle (Polisar et al., 2003).

Conclusions

Cattle ranches have the potential for maintaining a substantial part of the original chacoan fauna, where forest cover is a main component in the structuring of the mammal assemblages found around water reservoirs. High forest cover favors the occurrence and/or detectability of several threatened and non-threatened mammal species. This is especially the case for vulnerable *T. pecari* and *L. pardalis*, species that have been recognized as having roles in the functioning of ecosystems (Silman et al., 2003; Beck, 2005; Jorge et al., 2013; Periago et al., 2015; Galetti et al., 2015; Sarasola et al., 2016). In sites with high grassland cover and low

forest cover the generalist canid species *L. gymnocercus* and *C. thous* were quite common, indicating their ability to thrive in these anthropized habitats. The semiaquatic, *H. hydrochaeris* was by far the most commonly encountered species around water reservoirs. This observation confirms the expansion of its range toward the dry Chaco, which is linked to the proliferation of cattle ranches. (Campos-Krauer and Wisely, 2011). Higher detection probabilities for most of the species during the dry season indicates that artificial water reservoirs in cattle ranches are important infrastructures for wildlife when most of the natural bodies of water are ephemeral in the dry Chaco. The conservation of large forest tracts and strict compliance with poaching bans are key management strategies for the conservation of mammal diversity in the increasingly predominant human-altered landscapes of the Chaco.

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SUPPORTING INFORMATION

Figure S1. Scatterplot showing the correlation between forest cover and pasture cover in the study sites. Pearson coefficient was r= -0.998.

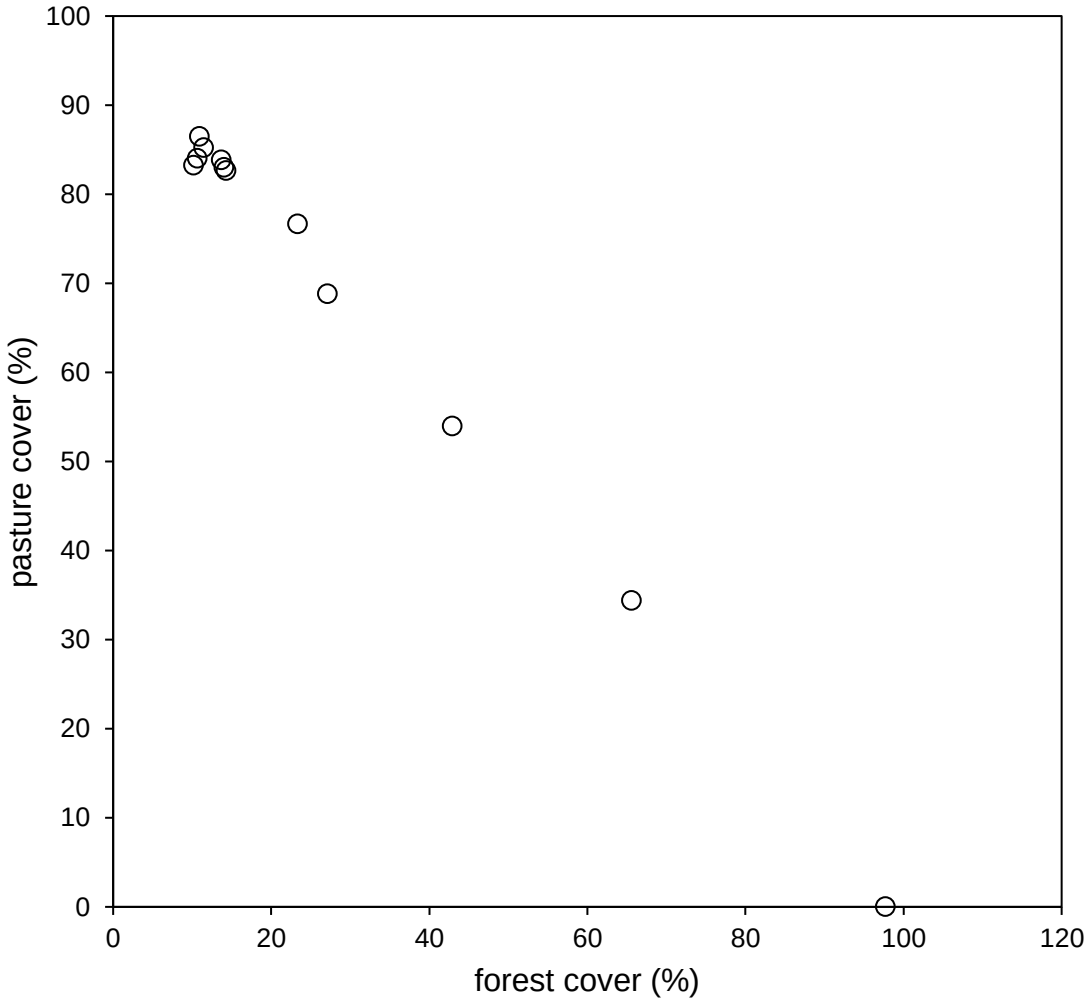


Table S1. Statistics of model selection for occupancy (psi) and detection probabilities (p) for each species. 'forest_cov'= forest cover (%); AICc / QAICc = Akaike and Quasi-Akaike information criteria corrected for small size; ΔAICc/ ΔQAICc = information distance from the highest ranked model; AICc/ QAICc wgt = model weight; *L* = relative model likelihood; *K* = number of parameters.

***Cerdocyon thous* (crab-eating fox)**						
Model	AICc	ΔAICc	AICc wgt	*L*	*K*	-2*LogLike
psi(.),p(forest_cov, season)	608.13	0	0.7094	1	4	600.13
psi(forest_cov),p(forest_cov, season)	610.13	2	0.261	0.3679	5	600.13
psi(.),p(forest_cov)	616.15	8.02	0.0129	0.0181	3	610.15
psi(.),p(season)	617	8.87	0.0084	0.0119	3	611
psi(forest_cov),p(forest_cov)	618.15	10.02	0.0047	0.0067	4	610.15
psi(forest_cov),p(season)	619	10.87	0.0031	0.0044	4	611
psi(.),p(.)	623.39	15.26	0.0003	0.0005	2	619.39
psi(forest_cov),p(.)	625.39	17.26	0.0001	0.0002	3	619.39

***Conepatus chinga* (Molina's hog-nosed skunk)**						
Model	AICc	ΔAICc	AICc wgt	*L*	*K*	-2*LogLike
psi(.),p(forest_cov, season)	272.89	0	0.6043	1	4	264.89
psi(forest_cov),p(forest_cov, season)	274.23	1.34	0.3092	0.5117	5	264.23
psi(forest_cov),p(season)	278.06	5.17	0.0456	0.0754	4	270.06
psi(.),p(season)	279.45	6.56	0.0227	0.0376	3	273.45
psi(.),p(forest_cov)	280.92	8.03	0.0109	0.018	3	274.92
psi(forest_cov),p(forest_cov)	282.3	9.41	0.0055	0.009	4	274.3
psi(forest_cov),p(.)	285.23	12.34	0.0013	0.0021	3	279.23
psi(.),p(.)	286.7	13.81	0.0006	0.001	2	282.7

***Hydrochaerus hydrochaeris* (capybara)**						
Model	AICc	ΔAICc	AICc wgt	*L*	*K*	-2*LogLike
psi(.),p(forest_cov, season)	732.18	0	0.5829	1	4	724.18
psi(forest_cov),p(forest_cov, season)	734.18	2	0.2144	0.3679	5	724.18
psi(.),p(forest_cov)	734.92	2.74	0.1481	0.2541	3	728.92
psi(forest_cov),p(forest_cov)	736.92	4.74	0.0545	0.0935	4	728.92
psi(.),p(.)	819.7	87.52	0	0	2	815.7
psi(.),p(season)	820.09	87.91	0	0	3	814.09
psi(forest_cov),p(.)	821.7	89.52	0	0	3	815.7
psi(forest_cov),p(season)	822.09	89.91	0	0	4	814.09

***Leopardus geoffroyi* (Geoffroy's cat)**						
Model	AICc	ΔAICc	AICc wgt	*L*	*K*	-2*LogLike
psi(.),p(season. forest_cov)	518.02	0	0.499	1	4	510.02

psi(forest_cov),p(forest_cov, season)	519.57	1.55	0.2299	0.4607	5	509.57
psi(.),p(season)	520.31	2.29	0.1588	0.3182	3	514.31
psi(forest_cov),p(season)	521.86	3.84	0.0732	0.1466	4	513.86
psi(.),p(forest_cov)	524.74	6.72	0.0173	0.0347	3	518.74
psi(.),p(.)	525.94	7.92	0.0095	0.0191	2	521.94
psi(forest_cov),p(forest_cov)	526.29	8.27	0.008	0.016	4	518.29
psi(forest_cov),p(.)	527.49	9.47	0.0044	0.0088	3	521.49

***Leopardus pardalis* (ocelot)**						
Model	AICc	ΔAICc	AICc wgt	*L*	*K*	-2*LogLike
psi(forest_cov),p(season)	107.28	0	0.5853	1	4	99.28
psi(forest_cov),p(forest_cov, season)	109.18	1.9	0.2264	0.3867	5	99.18
psi(.),p(season)	111.61	4.33	0.0672	0.1147	3	105.61
psi(forest_cov),p(.)	111.85	4.57	0.0596	0.1018	3	105.85
psi(.),p(forest_cov, season)	113.28	6	0.0291	0.0498	4	105.28
psi(forest_cov),p(forest_cov)	113.71	6.43	0.0235	0.0402	4	105.71
psi(.),p(.)	116.37	9.09	0.0062	0.0106	2	112.37
psi(.),p(forest_cov)	117.99	10.71	0.0028	0.0047	3	111.99

***Lycalopex gymnocercus* (pampas fox)**						
Model	QAICc	ΔQAICc	QAICc wgt	*L*	*K*	-2*LogLike
psi(.),p(forest_cov)	196.87	0	0.3688	1	3	339.81
psi(.),p(.)	198.52	1.65	0.1616	0.4382	2	346.39
psi(forest_cov),p(forest_cov)	198.76	1.89	0.1433	0.3887	4	339.61
psi(.),p(forest_cov, season)	198.82	1.95	0.1391	0.3772	4	339.73
psi(forest_cov),p(.)	200.39	3.52	0.0635	0.172	3	346.15
psi(.),p(season)	200.52	3.65	0.0595	0.1612	3	346.39
psi(forest_cov),p(forest_cov, season)	201.27	4.4	0.0409	0.1108	5	340.54
psi(forest_cov),p(season)	202.39	5.52	0.0233	0.0633	4	346.15

***Mazama gouazoubira* (gray brocket)**						
Model	AICc	ΔAICc	AICc wgt	*L*	*K*	-2*LogLike
psi(forest_cov),p(season)	388.31	0	0.3736	1	4	380.31
psi(.),p(season)	388.8	0.49	0.2924	0.7827	3	382.8
psi(forest_cov),p(forest_cov, season)	389.66	1.35	0.1902	0.5092	5	379.66
psi(.),p(forest_cov, season)	390.22	1.91	0.1438	0.3848	4	382.22
psi(forest_cov),p(.)	409.48	21.17	0	0	3	403.48
psi(.),p(.)	410.42	22.11	0	0	2	406.42
psi(forest_cov),p(forest_cov)	411.22	22.91	0	0	4	403.22
psi(.),p(forest_cov)	412.17	23.86	0	0	3	406.17

***Myrmecophaga tridactyla* (giant anteater)**

Model	AICc	ΔAICc	AICc wgt	*L*	*K*	-2*LogLike
psi(forest_cov),p(forest_cov)	131.85	0	0.2262	1	4	123.85
psi(.),p(forest_cov)	131.88	0.03	0.2228	0.9851	3	125.88
psi(forest_cov),p(.)	132.11	0.26	0.1986	0.8781	3	126.11
psi(.),p(forest_cov, season)	133.72	1.87	0.0888	0.3926	4	125.72
psi(forest_cov),p(forest_cov, season)	133.72	1.87	0.0888	0.3926	5	123.72
psi(forest_cov),p(season)	134.07	2.22	0.0745	0.3296	4	126.07
psi(.),p(.)	134.11	2.26	0.0731	0.323	2	130.11
psi(.),p(season)	136.09	4.24	0.0272	0.12	3	130.09

***Pecari tajacu* (collared peccary)**						
Model	AICc	ΔAICc	AICc wgt	*L*	*K*	-2*LogLike
psi(forest_cov),p(season)	294.59	0	0.2121	1	4	286.59
psi(forest_cov),p(.)	295.11	0.52	0.1635	0.7711	3	289.11
psi(forest_cov),p(forest_cov, season)	295.19	0.6	0.1571	0.7408	5	285.19
psi(.),p(season)	295.59	1	0.1286	0.6065	3	289.59
psi(.),p(.)	296.09	1.5	0.1002	0.4724	2	292.09
psi(.),p(forest_cov, season)	296.21	1.62	0.0943	0.4449	4	288.21
psi(forest_cov),p(forest_cov)	296.31	1.72	0.0897	0.4232	4	288.31
psi(.),p(forest_cov)	297.31	2.72	0.0544	0.2567	3	291.31

***Procyon cancrivorus* (crab-eating raccoon)**						
Model	QAICc	ΔQAICc	QAICc wgt	*L*	*K*	-2*LogLike
psi(.),p(forest_cov, season)	295.75	0	0.5027	1	4	431.83
psi(.),p(season)	297.33	1.58	0.2282	0.4538	3	437.24
psi(forest_cov),p(forest_cov, season)	297.75	2	0.1849	0.3679	5	431.83
psi(forest_cov),p(season)	299.33	3.58	0.0839	0.167	4	437.24
psi(.),p(forest_cov)	312.51	16.76	0.0001	0.0002	3	460.18
psi(forest_cov),p(forest_cov)	314.51	18.76	0	0.0001	4	460.18
psi(.),p(.)	315.32	19.57	0	0.0001	2	467.45
psi(forest_cov),p(.)	317.32	21.57	0	0	3	467.45

***Puma concolor* (puma)**						
Model	AICc	ΔAICc	AICc wgt	*L*	*K*	-2*LogLike
Lambda(.),c(forest_cov, season)	260.44	0	0.4453	1	4	252.44
Lambda(.),c(forest_cov)	260.8	0.36	0.3719	0.8353	3	254.8
Lambda(bq),c(forest_cov)	262.79	2.35	0.1375	0.3088	4	254.79
Lambda(.),c(.)	265.41	4.97	0.0371	0.0833	2	261.41
Lambda(.),c(season)	268.42	7.98	0.0082	0.0185	3	262.42
Lambda(bq),c(season)	311.66	51.22	0	0	4	303.66
Lambda(bq),c(forest_cov, season)	366.67	106.23	0	0	5	356.67

Lambda(bq),c(.)	555.26	294.82	0	0	3	549.26

***Tapirus terrestris* (tapir)**						
Model	AICc	ΔAICc	AICc wgt	*L*	*K*	-2*LogLike
psi(.),p(forest_cov)	467.19	0	0.3872	1	3	461.19
psi(forest_cov),p(forest_cov)	467.45	0.26	0.34	0.8781	4	459.45
psi(.),p(forest_cov, season)	469.15	1.96	0.1453	0.3753	4	461.15
psi(forest_cov),p(forest_cov, season)	469.41	2.22	0.1276	0.3296	5	459.41
psi(.),p(.)	495.04	27.85	0	0	2	491.04
psi(forest_cov),p(.)	495.26	28.07	0	0	3	489.26
psi(.),p(season)	496.67	29.48	0	0	3	490.67
psi(forest_cov),p(season)	496.89	29.7	0	0	4	488.89

***Tayassu pecari* (white-lipped pecari)**						
Model	QAICc	ΔQAICc	QAICc wgt	*L*	*K*	-2*LogLike
psi(forest_cov),p(forest_cov, season)	140.86	0	0.5917	1	5	187.7
psi(forest_cov),p(forest_cov)	142.46	1.6	0.2659	0.4493	4	192.94
psi(.),p(forest_cov, season)	145.26	4.4	0.0656	0.1108	4	197.02
psi(forest_cov),p(season)	146.5	5.64	0.0353	0.0596	4	198.83
psi(.),p(forest_cov)	146.88	6.02	0.0292	0.0493	3	202.29
psi(forest_cov),p(.)	149.12	8.26	0.0095	0.0161	3	205.55
psi(.),p(season)	151.97	11.11	0.0023	0.0039	3	209.71
psi(.),p(.)	154.63	13.77	0.0006	0.001	2	216.5

***Tolypeutes matacus* (southern three-banded armadillo)**						
Model	AICc	ΔAICc	AICc wgt	*L*	*K*	-2*LogLike
psi(.),p(.)	360.68	0	0.2813	1	2	356.68
psi(forest_cov),p(.)	361.56	0.88	0.1812	0.644	3	355.56
psi(.),p(forest_cov)	361.85	1.17	0.1567	0.5571	3	355.85
psi(.),p(season)	362.58	1.9	0.1088	0.3867	3	356.58
psi(forest_cov),p(forest_cov)	362.69	2.01	0.103	0.366	4	354.69
psi(forest_cov),p(season)	363.46	2.78	0.0701	0.2491	4	355.46
psi(.),p(forest_cov, season)	363.78	3.1	0.0597	0.2122	4	355.78
psi(forest_cov),p(forest_cov, season)	364.62	3.94	0.0392	0.1395	5	354.62

Table S2. Overdispersion parameter (ĉ) of the full model [psi(forest_cov), p(forest_cov, season)] in the occupancy analyses using 1,000 bootstrap samples and p-value when null hypothesis is ĉ ≤ 1

Species	ĉ	P-value
Cerdocyon thous (crab-eating fox)	0.9887	0.5248
Conepatus chinga (Molina's hog-nosed skunk)	1.6400	0.1980
Hydrochaerus hydrochaeris (capybara)	0.9322	0.8911
Leopardus geoffroyi (Geoffroy's cat)	1.0576	0.4059
Leopardus pardalis (ocelot)	0.3683	0.9208
Lycalopex gymnocercus (pampas fox)	1.7992	**0.0396**
Mazama gouazoubira (gray brocket)	0.9197	0.4851
Myrmecophaga tridactyla (giant anteater)	0.0585	0.9406
Pecari tajacu (collared peccary)	1.2500	0.2673
Procyon cancrivorus (crab-eating raccoon)	1.5112	**0.0396**
Tapirus terrestris (tapir)	0.9461	0.5644
Tayassu pecari (white-lipped peccary)	1.4566	**0.0396**
Tolypeutes matacus (southern three-banded armadillo)	0.4085	0.4901

5. CHAPTER III:

FOREST AND FOREST STRIPS, KEY TOWARDS LONG TERM CONSERVATION OF MEDIUM AND LARGE SIZE MAMMALS IN PRODUCTIVE LANDSCAPES OF THE DRY CHACO.

BOSQUES Y FRANJAS FORESTALES, CLAVE PARA LA CONSERVACIÓN A LARGO PLAZO DE MAMÍFEROS MEDIANOS Y GRANDES EN PAISAJES PRODUCTIVOS DEL CHACO SECO.

ABSTRACT

Forest transformation into productive landscapes in Paraguay has led to economic development but also extensive deforestation, resulting in habitat loss and fragmentation. Modern policies regulate land use changes in the Paraguayan dry Chaco, requiring a tree cover of 35 to 50% in cattle ranches and agricultural fields. The landscape consists of scattered forest patches, pastures or croplands, water bodies, and forest strips surrounding each 100-hectare plot. However, the significance of these strips as corridors for mammals between patches remains unclear. This study assessed mammal occupancy and habitat use as forest strips moved away from forest patches, while considering the influence of landscape features such as water bodies, roads, and houses. Out of the 30 recorded medium and large-sized mammal species, their use of forest strips varied. Distance to forest patches strongly influenced mammal communities, with diversity decreasing as distance within forest strips increased. Forest specialist mammals, including *T. peccary, T. terrestris*, and *M. tridactyla*, showed a strong negative effect on occupancy, while the plastic *L. gymnocercus* showed a positive effect. Overall detection probabilities decreased with distance from the forest. Mammal use of forest strips near water bodies was higher, whereas roads and houses had a negative impact on usage of forest strips by certain mammal species. Protecting forests on private lands is crucial for conserving Dry Chaco mammals. While forest strips contribute to interconnecting forest patches, they are not effective corridors for the entire mammal community. To enhance habitat connectivity, the width and length of forest strips should be considered as well as waterbodies and roads placement.

6. GENERAL CONCLUSIONS

We assessed richness and the response of local biodiversity (birds and, medium to large-sized mammals) to habitat modifications due to cattle ranching development. Four main elements were identified at landscape level: forest, forest strips, waterbodies and pastures. Richness and species compositions of birds and mammals showed similar patterns of response to landscape structure and composition. That allows us to draw general conclusions.

1. Despite being a highly productive environment, Estancia Montania maintained a substantial part of the original Dry Chaco fauna, with 59,2% of bird species and 89% of mammal species compared with total expected richness in the study area. This includes migrant, endemic and endangered species.
2. Forest cover played a primary role in structuring bird' and mammals' communities. Reduction in forest cover has a negative impact on the richness and composition of birds and mammals, decreasing ecosystem services such as pest control, seed dispersal and pollination. It is critical to maintain the legally mandated 25% of pristine forest for biodiversity conservation.
3. Pastures exhibited lower species richness, and the communities were dominated by species with high adaptation capacity to human disturbances. Birds showed a high turnover when comparing forest and pasture communities.
4. Forest strips maintain some of the complexity of forest vegetation structure and showed to act as biological corridors. However, their value varied among species based on the length, width, management practices, and species characteristics. Wider strips are necessary to facilitate connectivity for forest specialist mammals between patches.

5. Water bodies acted as oases, attracting species from surrounding environments. They played an important role by providing a vital resource to wildlife during periods of drought when ephemeral natural water sources dry up. Therefore, water bodies were heavily utilized during the dry season.
6. Internal dust roads influenced the intensity of habitat use by mammals. The use of forest strips by forest specialist mammals decreased as they approached roads.

7. CONCLUSIONES GENERALES

Se evaluó la diversidad y respuesta de aves y mamíferos medianos y grandes a las modificaciones del hábitat en paisajes ganaderos del chaco central. Se identificaron cuatro elementos principales a nivel del paisaje: bosque, franjas de bosque, cuerpos de agua y pasturas. Tanto la riqueza como la composición de especies de aves y mamíferos mostraron patrones similares de respuesta a la estructura y composición del paisaje, lo que nos permite obtener conclusiones generales.

1. A pesar de ser un ambiente altamente productivo, Estancia Montania conservó una parte sustancial de la fauna original del Chaco Seco, con un 59,2% de aves y un 89% de mamíferos en comparación con la riqueza total esperada en el área de estudio. Esto incluye especies migratorias, endémicas y en peligro de extinción.
2. La cobertura forestal fue el componente principal en la estructuración de las comunidades de aves y mamíferos. La reducción en la cobertura forestal afectó negativamente la riqueza y composición de aves y mamíferos, disminuyendo los servicios ecosistémicos como el control de plagas, la dispersión de semillas y la polinización. Es fundamental mantener el 25% de bosque prístino establecido por ley para la conservación de la biodiversidad.
3. Las pasturas mostraron una menor riqueza de especies y las comunidades estuvieron dominadas por especies con alta capacidad de adaptación a las perturbaciones humanas. Las aves mostraron una alta rotación en la comparación de comunidades entre bosques y pastizales.
4. Las franjas de bosque conservan parte de la complejidad de la estructura vegetal del bosque y actúan como corredores biológicos. Sin embargo, no tienen el mismo valor

para todas las especies. La longitud y amplitud de la franja de bosque, las prácticas de manejo y las características de las especies determinan su valor. Se requieren franjas más amplias para permitir la conectividad de mamíferos especialistas en bosques entre parches.

5. Los cuerpos de agua funcionaron como oasis, atrayendo especies de los entornos circundantes. Los cuerpos de agua fueron importantes al proporcionar un recurso limitante para la vida silvestre cuando las fuentes de agua naturales efímeras se sequen, por lo tanto, se utilizaron intensivamente en la temporada seca.
6. Las carreteras internas de tierra afectan la intensidad del uso del hábitat por parte de los mamíferos. El uso de las franjas por parte de los mamíferos especialistas en bosques disminuye a medida que están más cerca de las carreteras.

8. RECOMENDATIONS

Preserve forest patches: Maintaining Forest patches within productive landscapes without cattle and favoring a single block patch design can help preserve biodiversity. This will contribute to the proper functioning of ecosystems and the long-term persistence of species.

Enhance connectivity: Improve connectivity between forest patches by modifying forest strip characteristics and implementing proper management practices. This will support the survival of many forest species over time.

Ensure waterbody perimeters: Maintain a clear segregation between wildlife and cattle by preserving the perimeters of waterbodies. This will enhance the ecological value of waterbodies and prevent the transmission of diseases between wildlife and livestock.

Rotate the livestock herd: Rotating the livestock herd facilitates herd control, promotes more efficient grazing of pastures, and allows resting pastures to regenerate herbaceous cover. At the same time, grouping the livestock enables biodiversity to utilize the pastures under rest, avoiding interaction with the cattle.

Promote arborization of pastures: Improve the biodiversity value of pastures by promoting the planting of native trees such as carob and quebracho. These trees provide shelter and food for both cattle and wildlife.

Environmental monitoring: Include environmental monitoring as an integral component of the annual operational plan for livestock ranches. Emphasize monitoring of endemic and endangered species. Implement measures that enhance conservation opportunities for these species.

As a conclusion to this work, I would like to express that the development and implementation of policies and activities that promote environmental conservation in productive landscapes should rely on science, while considering the socio-economic and cultural aspects of the country. The construction of policies, derived from exchanges between academia, producers, and the government, is essential to achieve sustainable development.

9. RECOMENDACIONES

Preservar los parches de bosque: Mantener los parches boscosos que se encuentran dentro del paisaje productivo sin ganado y favorecer un diseño de parche de bloque único ayuda a preservar la biodiversidad. Esto contribuirá al correcto funcionamiento de los ecosistemas y a la persistencia a largo plazo de las especies.

Mejorar la conectividad: Mejorar la conectividad entre los parches de bosque mediante la modificación de las características de algunas franjas forestales y la implementación de prácticas de manejo adecuadas. Esto favorecerá la supervivencia de muchas especies forestales a lo largo del tiempo.

Garantizar los perímetros de los cuerpos de agua: Mantener una segregación espacial entre la vida silvestre y el ganado mediante la preservación de los perímetros de los cuerpos de agua. Esto mejorará el valor ecológico de los cuerpos de agua y evitará la transmisión de enfermedades entre la vida silvestre y el ganado.

Promover la arborización de los pastizales: Mejorar el valor de biodiversidad de los pastizales promoviendo la plantación de árboles nativos como algarrobos y quebrachos. Estos árboles proporcionan refugio y alimento tanto para el ganado como para la vida silvestre.

Monitoreo ambiental: Incluir el monitoreo ambiental como componente integral del plan operativo anual de las explotaciones ganaderas. Hacer hincapié en el monitoreo de especies endémicas y en peligro de extinción. Implementar medidas que mejoren las oportunidades de conservación para estas especies.

Al implementar estas recomendaciones, los productores ganaderos pueden contribuir al mantenimiento de la biodiversidad local, promover una producción sostenible y apoyar la viabilidad a largo plazo de sus operaciones.

Como cierre de este trabajo me gustaría expresar que para el desarrollo e implementación de políticas y actividades que fomenten la conservación del medioambiente en entornos productivos deben basarse en la ciencia, además de considerar los aspectos socioeconómicos y culturales del país. La construcción de políticas, derivadas de los espacios de intercambio entre la academia, los productores y el gobierno, son fundamentales para lograr un desarrollo sostenible.

10. FINAL APPENDIX: FIELD WORK AND SOCIAL OUTREACH OF RESULTS

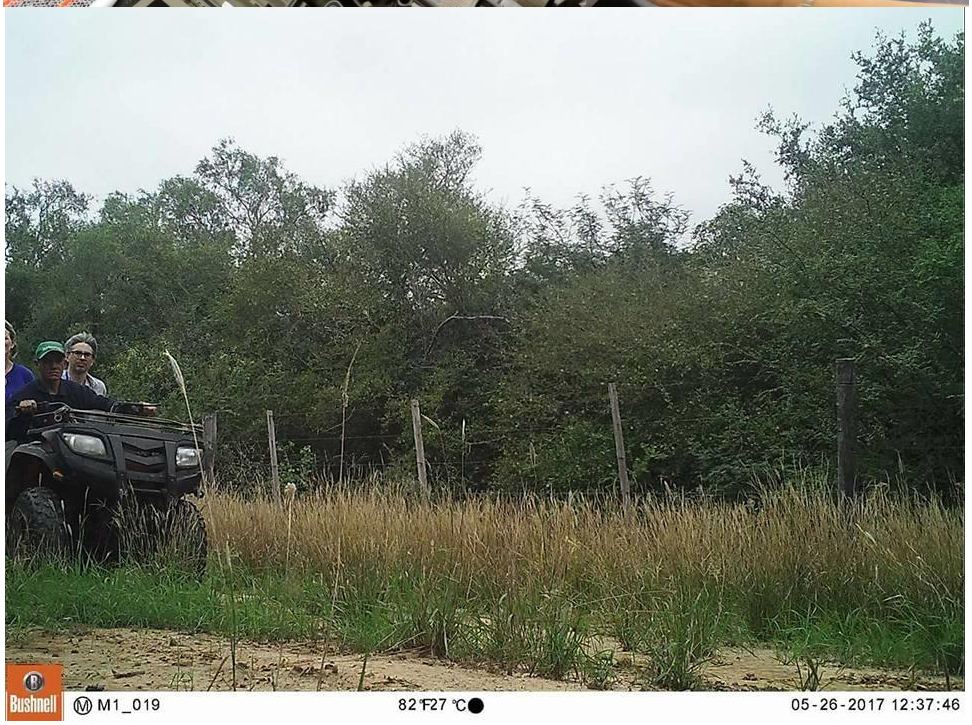
ANEXO FINAL: TRABAJO DE CAMPO Y DIFUSION A LA SOCIEDAD

FIELD WORK

The data collection activities in the field were accompanied by collaborators, both biologists and local guides. All the equipment were set up and programmed before going out on the field.

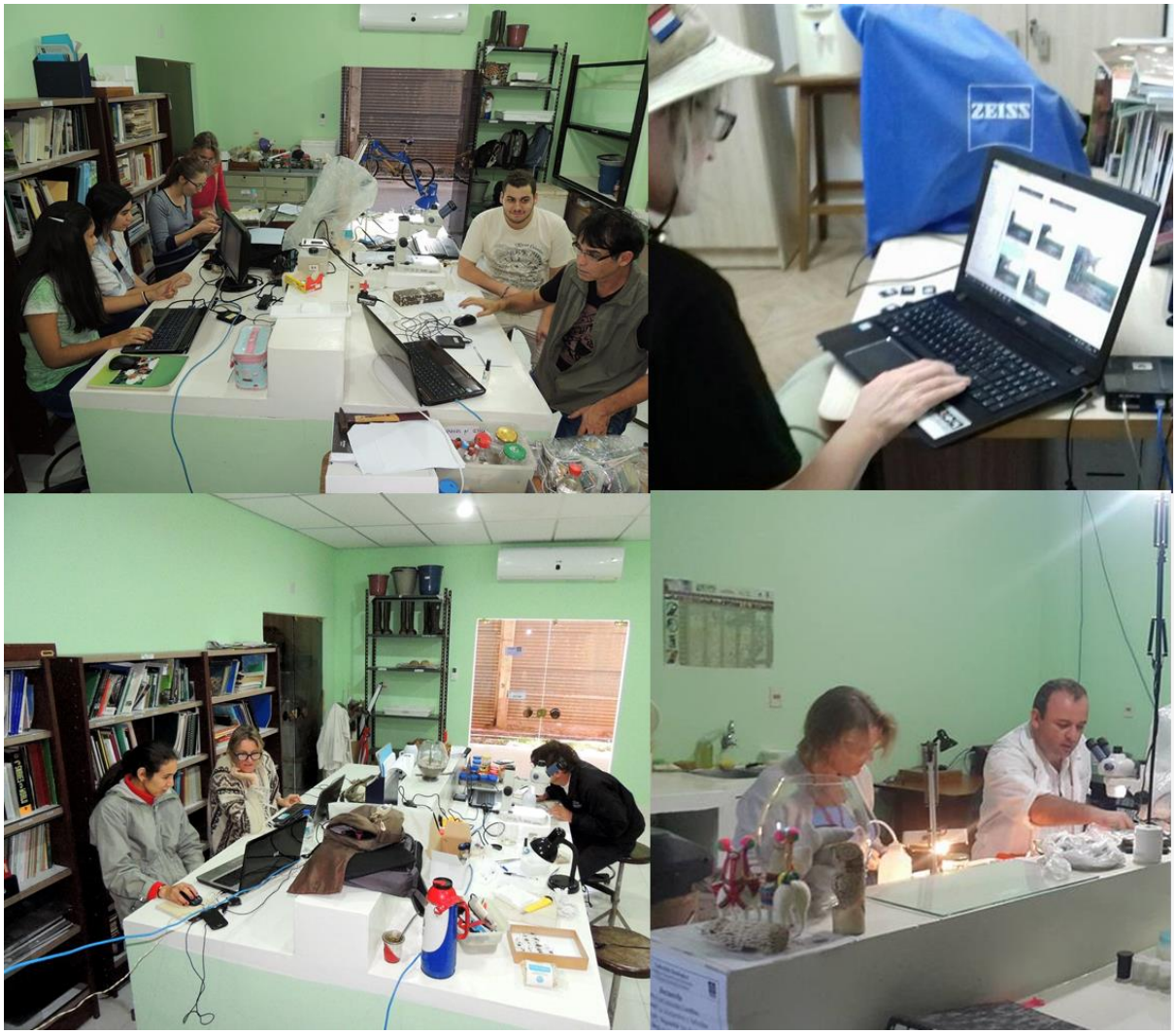
TRABAJO DE CAMPO

Las actividades de toma de datos en campo fueron acompañadas por colaboradores, tanto biólogos como guías locales. Todos los equipos fueron puestos a punto y programados antes de salir al campo.



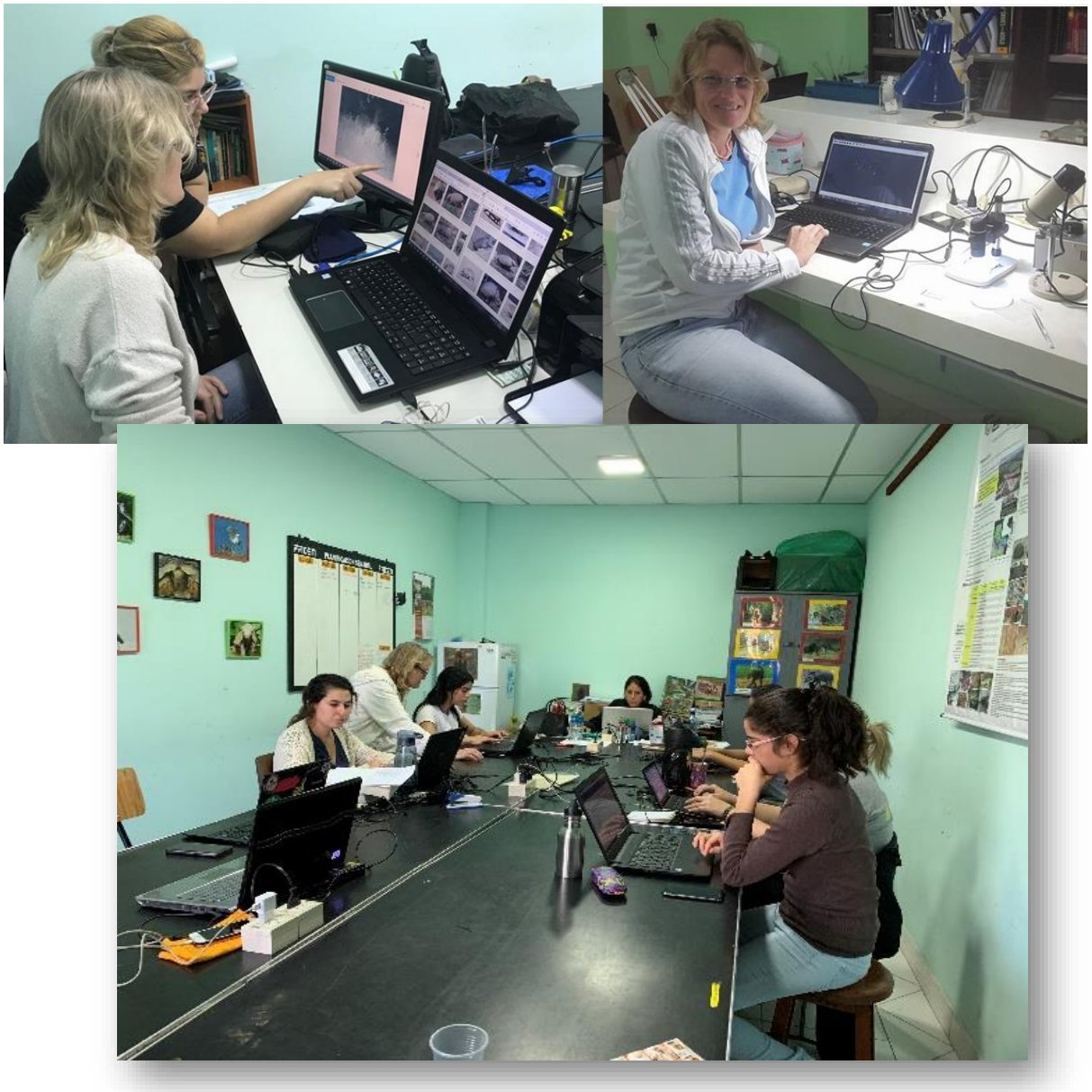
LABORATORY WORK

Once in the laboratory, the processing of the field data was carried out by the researchers and with the collaboration of biology students who were doing internships in the Zoology Laboratory.



Trabajo de Laboratorio

Una vez en el laboratorio, el procesamiento de los datos de campo fue realizado por los investigadore y con la colaboración de estudiantes de la carrera de biología que se encontraban realizando pasantías en el Laboratorio de Zoología.



MEDIUM AND LARGED-SIZED MAMMALS WITH COMMONS NAMES IN GUARANI

MAMÍFEROS MEDIANOS Y GRANDES CON SUS NOMBRES COMUNES EN GUARANI

ORDER PILOSA

A. Myrmecophaga tridactyla – Jurumi

B. Tamandua tetradactyla – Kaguare

ORDER LEPORIDAE

A. *Sylvilagus brasiliensis* – Tapiti

ORDER CINGULATA

A. *Chaetophractus vellerosus* – Tatu kirisi
B. *Tolypeutes matacus* – Tatu volita
C. *Euphractus sexcinctus* – Tatu poju
D. *Chaetophractus villosus* – Tatu poju'i
E. *Dasypus novemcinctus* – Tatu hũ
F. *Priodontes maximus* – Tatu karreta

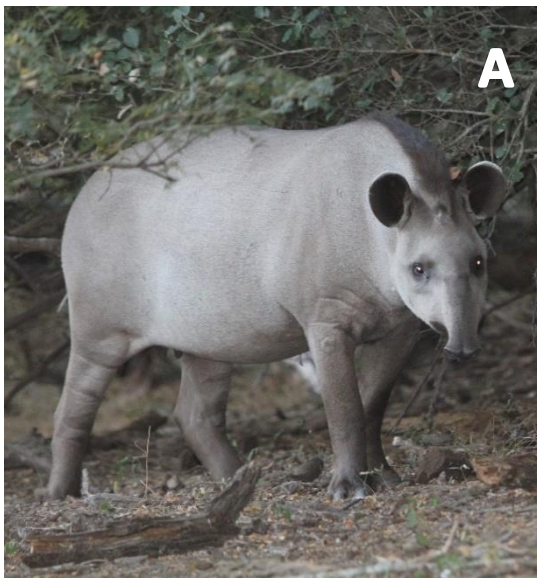
ORDER ARTIODACTYLA

A. *Tayassu pecari*- Tañy katĩ
B. *Pecari tajacu* – Kure'i
C. *Catagonus wagneri*- Tagua
D. *Mazama gouazoubira* – Guasu vira

ORDER RODENTIA

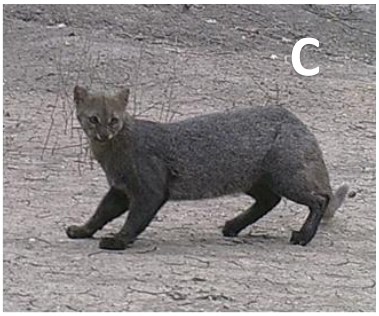
A. *Hydrochoerus hydrochaeris*- Kapi'yva
B. *Ctenomys conoveri* – Tuka tuka
C. *Dolichotis salinicola* – Tapiti voli

ORDER PERISSODACTYLA



Tapirus terrestris – Mborevi

ORDER CARNIVORA



A. *Leopardus pardalis*- Jaguarete'i
B. *Leopardus geoffroyi* – Tirika
C. *Puma yagouaroundi* – Jaguarundi
D. *Puma concolor* – Jagua pytã
E. *Panthera onca* – Jaguarete
F. *Lycalopex gymnocercus* – Aguara cha'i
G. *Cerdocyon thous* – Aguara'i
H. *Procyon cancrivorus* – Aguara pope
I. *Conepatus chinga* - Jagua ne
J. *Eira barbara* – Eira
K. *Galictis cuja*- Jagua pe

TALKS WITH PRODUCERS

Once in the laboratory, the processing of the field data was carried out by the researchers, with the collaboration of biology students who were doing internships in the Zoology Laboratory. The talks with producers were carried out in an informal and unstructured way whenever there was a possibility. Through these interactions, we shared the results of the monitoring and updated the progress status of the project. We also shared our experiences with neighbors as a means of instilling the idea of the importance of understanding how our actions affect local biodiversity and the practices that could be implemented to reduce the impact.

CHARLAS CON PRODUCTORES

Las charlas con productores se realizaron de manera informal y no estructurada, cada vez que hubo posibilidad. A travez de estos especios le contamos los resultados de los monitoreos y el estado de avance del proyecto. Tambien compartimos las experiencais con vecions a modo de in instalando la idea de la importancia de comprender como nuestras acciones afectan a la biodiversidad local y las prácticas que podrían implementar para disminuir el impacto.

On the other hand, conferences were held at the Rural Association of Paraguay, organized by the Environment Commission. Likewise, we also participated in the Field Trip to Estancia Montania, where we presented the results of the project to the agricultural producers.

Por otro lado, se llevaron adelante conferencias en la Asociación Rural del Paraguay, organizada por la Comisión de Medio Ambiente. Asimismo, participando también en la Salida de Campo de Estancia Montania donde presentamos los resultados del proyecto a los productores agropecuarios.

SCIENTIFIC CONFERENCES / CONFERENCIAS CIENTIFICAS

The results of the work were presented at national and regional conferences such as the III Paraguayan Symposium on Mammalogy, the XXXII Brazilian Congress of Zoology, and the III Researchers' Meeting.

SOCIEDAD CIENTÍFICA DEL PARAGUAY

Certifica que:

Andrea Weiler, Karina Núñez, Fernando Cubilla, Salvador Peris, Fernando Silla, Fátima Mereles
Speaker

Presentaron el trabajo titulado

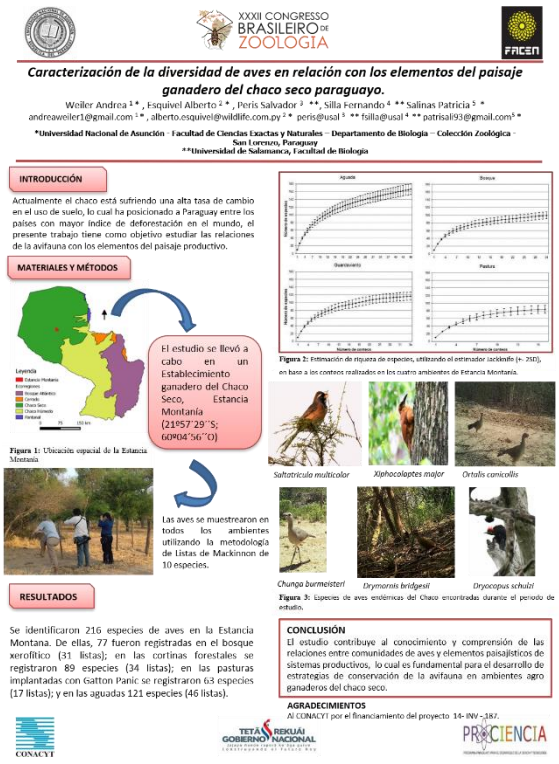
"Determinación del valor de paisajes ganaderos en la conservación de la biodiversidad del chaco seco Paraguayo". - PRESENTACIÓN ORAL

En el **II Encuentro de Investigadores: Construyendo el Conocimiento Científico en el Paraguay** que se llevó a cabo del 22 al 25 de agosto de 2017 en las instalaciones de la Sociedad Científica del Paraguay,

Asunción - Paraguay

Dra. Antonieta Rojas de Arias
Presidenta
Sociedad Científica del Paraguay

Dra. Marta Ascurra
Secretaria
Sociedad Científica del Paraguay



XXXII CONGRESSO BRASILEIRO DE ZOOLOGIA

Caracterización de la diversidad de aves en relación con los elementos del paisaje ganadero del chaco seco paraguayo.

Weiler Andrea [1] *, Esquivel Alberto [2] *, Peris Salvador [3] **, Silla Fernando [4] ** Salinas Patricia [5] *
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*Universidad Nacional de Asunción - Facultad de Ciencias Exactas y Naturales - Departamento de Biología - Colección Zoológica - San Lorenzo, Paraguay
**Universidad de Salamanca, Facultad de Biología

INTRODUCCIÓN

Actualmente el chaco está sufriendo una alta tasa de cambio en el uso de suelo, lo cual ha posicionado a Paraguay entre los países con mayor índice de deforestación en el mundo, el presente trabajo tiene como objetivo estudiar las relaciones de la avifauna con los elementos del paisaje productivo.

MATERIALES Y MÉTODOS

El estudio se llevó a cabo en un Establecimiento ganadero del Chaco Seco, Estancia Montanía (21°57'29''S; 60°04'56''O)

Figura 1: Ubicación espacial de la Estancia Montanía

Las aves se muestrearon en todos los ambientes utilizando la metodología de Listas de Mackinnon de 10 especies.

RESULTADOS

Se identificaron 216 especies de aves en la Estancia Montana. De ellas, 77 fueron registradas en el bosque xerofítico (31 listas); en las cortinas forestales se registraron 89 especies (34 listas); en las pasturas implantadas con Gatton Panic se registraron 63 especies (17 listas); y en las aguadas 121 especies (46 listas).

Figura 2: Estimación de riqueza de especies, utilizando el estimador Jackknife (+- 2SD), en base a los conteos realizados en los cuatro ambientes de Estancia Montanía.

Saltatricula multicolor *Xiphocolaptes major* *Ortalis canicollis*

Chunga burmeisteri *Drymornis bridgesii* *Dryocopus schulzi*

Figura 3: Especies de aves endémicas del Chaco encontradas durante el periodo de estudio.

CONCLUSIÓN

El estudio contribuye al conocimiento y comprensión de las relaciones entre comunidades de aves y elementos paisajísticos de sistemas productivos, lo cual es fundamental para el desarrollo de estrategias de conservación de la avifauna en ambientes agro ganaderos del chaco seco.

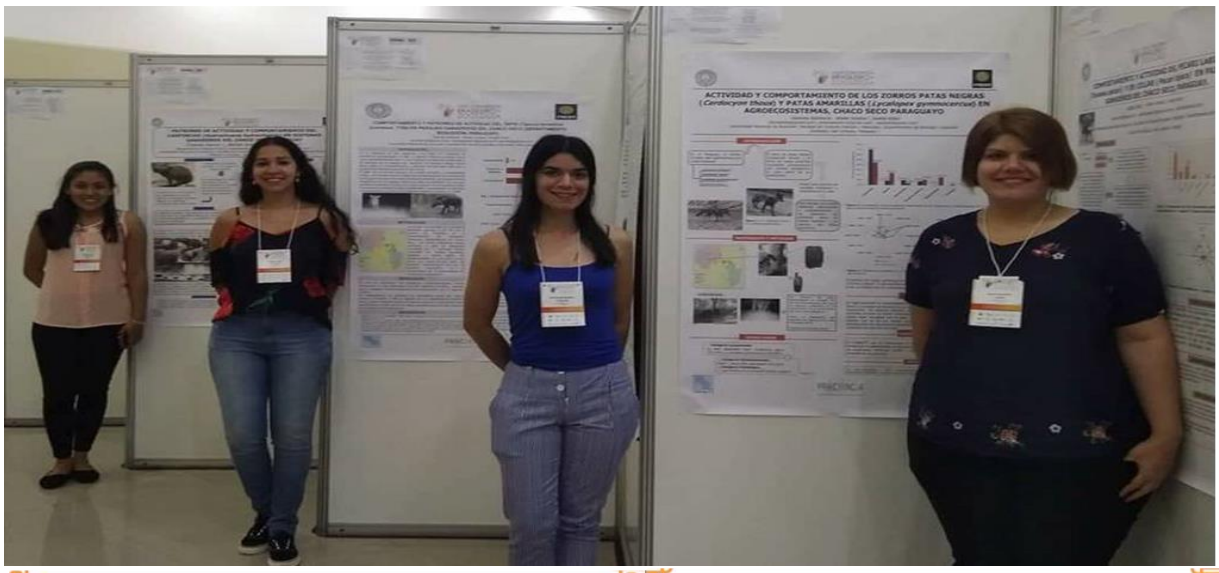
AGRADECIMIENTOS

Al CONACYT por el financiamiento del proyecto 14- INV -187.

EDUCATION

During the development of the thesis, the project and the amount of data generated were also utilized to initiate biology students into science through the scientific initiation program.

Durante el desarrollo de la tesis, también se aprovechó el proyecto y la cantidad de datos generados para iniciar estudiantes de biología en ciencias.




XXXII CONGRESSO BRASILEIRO DE ZOOLOGIA
FOZ DO IGUAÇU 2018

Certificamos que o trabalho intitulado "Comportamiento y actividad del pecarí labiado, *Tayassu pecari* (Link, 1795), y de collar, *Pecari tajacu* (Linnaeus, 1758) en paisajes ganaderos del chaco seco, Paraguay", de autoria de BELÉN ZALDIVAR , ANDREA WEILER e KATIA AIRALDI, foi apresentado no XXXII Congresso Brasileiro de Zoologia, na modalidade "pôster".

Foz do Iguaçu, Paraná, Brasil, 26 de fevereiro a 02 de março de 2018.

Prof. Dr. Fernando César Vieira Zanella
Presidente do XXXII CBZ

Profª Drª Luciane Marinoni
Presidente da Sociedade Brasileira de Zoologia

XXXII CONGRESSO BRASILEIRO DE ZOOLOGIA
FOZ DO IGUAÇU 2018

Certificamos que o trabalho intitulado "Actividad y comportamiento de los zorros patas negras *Cerdocyon thous* (L.), y patas amarillas, *Lycalopex gymnocercus* G. Fischer, en agroecosistemas, chaco seco paraguayo", de autoria de ESTEFANIA VALIENTE, ANDREA WEILER e KATIA AIRALDI, foi apresentado no XXXII Congresso Brasileiro de Zoologia, na modalidade "pôster".

Foz do Iguaçu, Paraná, Brasil, 26 de fevereiro a 02 de março de 2018.

Prof. Dr. Fernando César Vieira Zanella
Presidente do XXXII CBZ

Profª Drª Luciane Marinoni
Presidente da Sociedade Brasileira de Zoologia

XXXII CONGRESSO BRASILEIRO DE ZOOLOGIA
FOZ DO IGUAÇU 2018

Certificamos que o trabalho intitulado "Patrones de actividad diaria y comportamiento del carpincho [*Hydrochoerus hydrochaeris* (L.)] en sistemas ganaderos del chaco seco, Paraguay", de autoria de KAREN CHAVEZ, ANDREA WEILER e KATIA AIRALDI, foi apresentado no XXXII Congresso Brasileiro de Zoologia, na modalidade "pôster".

Foz do Iguaçu, Paraná, Brasil, 26 de fevereiro a 02 de março de 2018.

Prof. Dr. Fernando César Vieira Zanella
Presidente do XXXII CBZ

Profª Drª Luciane Marinoni
Presidente da Sociedade Brasileira de Zoologia

XXXII CONGRESSO BRASILEIRO DE ZOOLOGIA
FOZ DO IGUAÇU 2018

Certificamos que o trabalho intitulado "Comportamiento y patrones de actividad diaria del tapir *Tapirus terrestris* (Linnaeus, 1758) en paisajes ganaderos del chaco seco (Boquerón, Paraguay)", de autoria de YOLANDA RAMOS, ANDREA WEILER e KATIA AIRALDI, foi apresentado no XXXII Congresso Brasileiro de Zoologia, na modalidade "pôster".

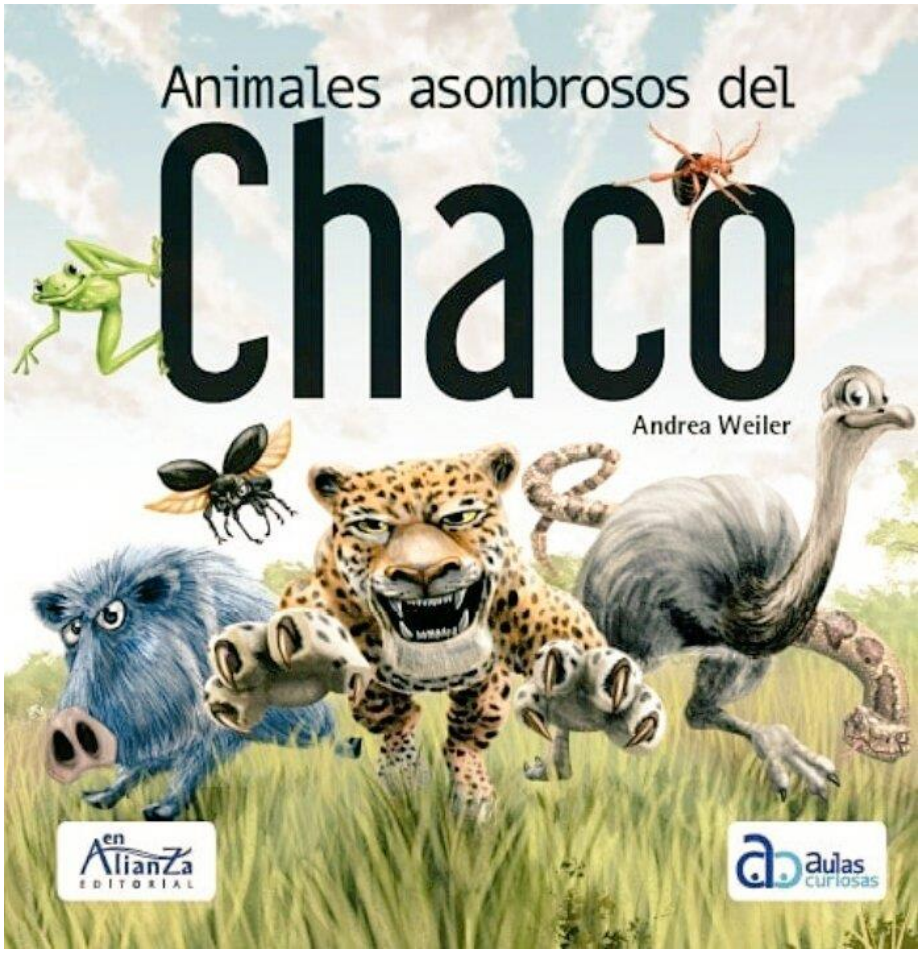
Foz do Iguaçu, Paraná, Brasil, 26 de fevereiro a 02 de março de 2018.

Prof. Dr. Fernando César Vieira Zanella
Presidente do XXXII CBZ

Profª Drª Luciane Marinoni
Presidente da Sociedade Brasileira de Zoologia

Amazing animals of the Chaco

As an initiative to foster curiosity and a love for nature in children and young people, we have prepared a book that explores the unique features of the fauna in the Chaco region. The book recounts intriguing stories such as a beetle that can launch a chemical bomb, an animal that miraculously survives even when torn apart, the feline with the most powerful bite, a frog that uses sunscreen, and the heir bird of the extinct terror birds. These remarkable creatures are not from a movie but are the incredible and real inhabitants of the Paraguayan Chaco, the most arid area. This book is perfect for nature enthusiasts who want to delve deeper into these fascinating tales.



Animales asombrosos del Chaco

Como iniciativa para promover la curiosidad y el amor por la naturaleza en niños y jóvenes, hemos elaborado un libro que relata algunas peculiaridades de la fauna chaqueña.

Breve reseña. ¿Un escarabajo capaz de lanzar una bomba química? ¿Un animal que sigue viviendo, aunque lo hayan despedazado? ¿El felino de la mordida más poderosa? ¿Una rana que usa protector solar? ¿El pájaro heredero de las aves del terror? No son animales de película, sino los asombrosos y reales habitantes de la zona más árida del Chaco paraguayo. Un libro para los que aman la naturaleza y quieren saber más.

Mammal Identification Guide

Based on the results of camera trapping and the limited knowledge of species inhabiting productive agricultural environments in the dry Chaco, we have prepared a guidebook that features 41 species of medium and large mammals identified by their scientific and common names. Each species is accompanied by a description of its characteristics and life history, supplemented with iconography illustrating their activity patterns, diet, and conservation status. The guidebook also includes information on the species' distribution areas and a size comparison with humans. The work concludes with recommendations for implementing good practices to conserve biodiversity in agricultural environments, providing producers with a pathway towards greater sustainability on their properties. The Ministry of the Environment and Sustainable Development, the National Council of Science and Technology, the Faculty of Exact and Natural Sciences of the National University of Asunción, the Scientific Society of Paraguay, and the Paraguayan Association of Mammalogy have all declared this work to be of scientific and educational interest.


LA NACIÓN

#TransicióndeGobierno #ExpoMRA2023 #ElegidosPy #Congreso 23/28

Un libro para conocer más sobre los animales que habitan en el Chaco

ESTILO DE VIDA 23 DE ABRIL DE 2020, 12:10

Día del libro: descargá gratis la Guía de Vida Silvestre Chaqueña

Compartir en redes

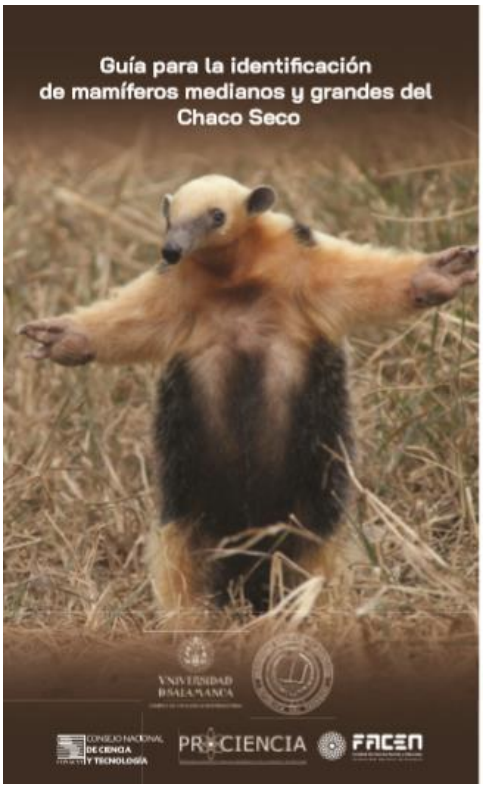
La bióloga Andrea Weiler junto a otros profesionales paraguayos y españoles realizaron el lanzamiento de la "Guía para la identificación de mamíferos medianos y grandes del Chaco Seco".

Por: Jazmín Gómez Fleitas

Guía para la identificación de mamíferos

En base a los resultados de fototrampeo y al poco conocimiento de las especies que habitan en ambientes productivos agropecuarios en el Chaco seco, elaboramos una guía que contiene 41 especies de mamíferos medianos y grandes identificado por sus nombres científicos y comunes. La descripción de cada especie y su historia de vida, esta acompañada de iconografías que indican sus patrones de actividad, su dieta y estado de conservación. Contiene también el área de distribución de la especie y una referencia de su tamaño en comparación con el ser humano. La obra finaliza con recomendaciones de buenas prácticas para la conservación de la biodiversidad en ambientes agropecuarios, lo que permite a los productores aproximarse a una visión de mayor sostenibilidad para sus establecimientos.

La obra fue declarada de interés científico y educativo por el Ministerio del Ambiente y Desarrollo Sostenible, El Consejo Nacional de Ciencia y Tecnología, la Facultad de Ciencias Exactas y Naturales de la Universidad Nacional de Asunción, la Sociedad Científica del Paraguay y la Asociación Paraguaya de Mastozoología.



Citizen awareness activities

Science week: Activity of the Faculty of Exact and Natural Sciences, through which the researchers of the faculty interact with society.

Actividades de concientización con la ciudadanía

Semana de la ciencia: Actividad de la Facultad de Ciencias Exactas y Naturales, a través de la cual, los investigadores de la facultad interactúan con la sociedad.

We have been engaged in delivering talks and participating in conferences at various events that promote agricultural activities. Some examples include the Livestock Exhibition organized by the Rural Association of Paraguay, the Green Chaco Paraguay fair, and educational talks conducted in schools.

Charlas y conferencias en distintos eventos que promueven actividades agropecuarias como fueron: La Exposición ganadera organizada por la Asociación Rural del Paraguay, La feria Green Chaco Paraguay y charlas educativas en colegios.

AWARDS

National Science Award

The "National Science Award" is the most important award in research and development that the Paraguayan Government grants to scientists who have contributed to knowledge. In its 2020 edition, the chapter of this thesis "Forest Matters: use of water reservoirs by mammals' communities in a cattle ranch landscape of the Paraguayan Dry Chaco" obtained an honorable mention. The award was given by the head of state Mario Abdo Benítez and was held at the Government Palace.

REPUBLICA DEL PARAGUAY

CONGRESO NACIONAL

PREMIO NACIONAL DE CIENCIA 2020

Por cuanto el Jurado ha reconocido el especial mérito a la obra

"Los bosques importan: uso de reservorios de agua por comunidades de mamíferos en paisajes de estancias ganaderas en el chaco seco paraguayo", titulada originalmente como: "Forest matters: use of water reservoirs by mammal communities in cattle ranch landscapes in the Paraguayan Dry Chaco".

Se otorga la presente mención de honor a sus autores:

Andrea Weiler, Karina Núñez y Fernando Silla.

Asunción, Octubre de 2020

Senadora Blanca Ovelar
Presidenta
Comisión de Cultura, Educación, Ciencias, Tecnología y Deportes
Honorable Cámara de Senadores

Senador Cesar Salomón
Presidente
Congreso Nacional

Prof. Dr. Esteban Ferro
Jurado

Prof. Ing. Luis Fernando Meyer
Jurado

Prof. Dra. Magdalena Rivarola
Jurado

Prof. Dra. Estima Mereles
Jurado

Prof. Dr. Francisco Santa Cruz
Jurado

Premio Nacional de Ciencias

El “Premio Nacional de Ciencia” es el galardón más importante en materia de investigación y desarrollo que otorga el Gobierno paraguayo a las científicas y científicos que han contribuido al conocimiento. En su edición 2020, el capítulo de esta tesis “Forest Matters: use of water reservoirs by mammals’ communities in a cattle ranch landscape of the Paraguayan Dry Chaco” obtuvo una mención de honor. La premiación estuvo a cargo del jefe de estado Mario Abdo Benítez y se realizó en Palacio de Gobierno.

Carol and James Patton Awards

The American Society of Mammologists (ASM), through its International Relations Committee, seeks to promote the growth of mammalogy in Latin America by fostering connections between ASM members and Latin American mammologists. In that spirit, ASM offers the Carol and James Patton Awards to an outstanding graduate student from each of the Latin American Mamma Society.

Premios Carol y James Patton

La American Society of Mammalogists (ASM), a través de su Comité de Relaciones Internacionales, busca promover el crecimiento de la mastozoología en América Latina fomentando las conexiones entre los miembros de la ASM y mastozoólogos latinoamericanos. En ese espíritu, la ASM ofrece los Premios Carol y James Patton a un estudiante graduado destacado de cada una de las sociedades de mastozoólogos de Latinoamérica.

III Meeting of researchers

The purpose of the event is to create a multidisciplinary space in which scientific production is developed, covering all areas of science produced in Paraguay, and to share them among peers and society in general. The works from the areas of Health Sciences and Biomedicine, Social Sciences and Humanities, Agricultural and Natural Sciences, Physical-Mathematical Sciences, and Engineering will be presented in oral and poster formats. These works have been evaluated by peers and distinguished with honorable mentions in their respective areas of science.

III Encuentro de investigadores:

El evento tiene por finalidad crear un espacio multidisciplinario en el que se desarrolle la producción científica abarcando todas las áreas de las ciencias producidas en Paraguay y compartirlos entre los pares y la sociedad en general. Los trabajos de las áreas de Ciencias de la Salud y Biomedicina, Ciencias Sociales y Humanidades, Ciencias Agrarias y Naturales, Ciencias Físico-Matemáticas e Ingenierías se presentarán en formato oral y poster, fueron evaluados por pares y distinguidos con menciones de honor por área de la ciencia.