

# Glasgow University Bolivia Expedition Report 2010

A Joint Glasgow University & Bolivian  
Expedition to the Beni Savannahs of Bolivia

Edited by Joanne Kingsbury



# Foreword

It is with great pride and pleasure that I present this report which compiles the results of research conducted by the Glasgow University Exploration Society, Bolivia Expedition 2010. This document details the methodologies, findings and conclusions of the research projects carried out by the 2010 expedition team and provides background information, logistical reports and future recommendations for the project as a whole.

This document marks the second successful Glasgow University Expedition to the Barba Azul Nature Reserve in the Beni Savannah region of Northern Bolivia, an area considered an endangered critical ecosystem by the Nature Conservancy. It builds significantly upon the research work of the 2009 Glasgow University expedition team whose preliminary explorations yielded baseline inventory data for the reserves avian, mammalian and herpetological fauna and hence provided the foundations for this years study. Our work is conducted alongside the local Birdlife International partner Association Armonia, who have supported and facilitated the Expeditions research in the region. It is hoped that our research will assist them with their goal to efficiently and effectively manage the reserves biodiversity. Further, by utilizing local scientists and students as part of our survey teams, we hope to stimulate local scientific interest and research within the region that will ensure protection of this fragile region for generations to come.

The primary aim of this years study was to conduct surveys of key avian and mammalian conservation species, known from prior research to be present on the Barba Azul Reserve. We aimed to determine and map the distribution of threatened savannah passerines in relation to the botanical structure and composition of the Savannah habitat in order to allow assessment of the ecological significance of microhabitats for such species. We also aimed to produce population abundance and density estimates for both threatened savannah passerines and other key avian species within the reserve, including the critically endangered blue throated macaw and white winged nightjar. Further we aimed to create abundance indices for the reserves mammalian fauna specifically focusing on threatened and vulnerable species such as giant anteater and pampas deer. Lastly, we aimed to continue with the collection of baseline inventory data for the mammalian fauna of the reserve but this year including bats.

Together, these studies were conducted in order to establish both the importance of the reserve for key conservation species while also providing a baseline for the future monitoring of their population structure and size over time. As this is first time that such factors have been assessed in the area, our research will provide the foundations for future monitoring and study.

Joanne Kingsbury

# Acknowledgements

First and foremost, the 2010 expedition team would like to thank Dr Ross Macleod for providing us the opportunity to work on such a fascinating and important project and also for his constant support, advice and encouragement throughout. Equally, we extend our thanks to the funders who supported the project financially, namely: Glasgow University, The Royal Geographical Society, The Royal Scottish Geographical Society, Chester Zoo, The Gilchrist Trust, The Carnegie Trust, Glasgow Natural History Society and The Thriplow Charitable Trust. Without the generous contributions and support of these bodies, our research would never have been possible.

Thank you also to the team of Bolivian scientists who provided their assistance and advice in the field, particularly: project botanist Aquilino Molina Olivera; ornithologist, Miguel Angel Aponte Justiniano; mammalogist, Luis Hernan Acosta Salvatierra and student, Francisco Morezapiri. A finer bunch, we could not have wished for. We hope they will continue to work alongside the Glasgow University expedition teams in future.

Additionally, we would like to express our deepest gratitude to the team at Armonia chiefly, Bennett Hennessey and Mauricio Herrera for facilitating and supporting our work in the Reserva Barba Azul. Special thanks also to Gustavo Sanchez Avila, who has afforded much time and effort in assisting the Bolivia expeditions over the years. Also to Douglas Bruckner who drove us anywhere we wanted to go and who will be sadly missed next year. Lastly, to Hernan “Nancho” Vargas and “Cachupo” for looking out for us, teaching us rodeo skills and keeping us from being eaten by jaguars!

Finally, thanks to all of those people who supported, promoted or assisted the expedition prior to its departure, specifically: Dr Kevin Murphy for his assistance in botanical planning; Professor Roger Downie and Dr Stewart White, for their recommendations; The Graham Kerr janitor, George for staying late and not getting paid; The band members who played for free to assist in our fund raising nights and the good students of Glasgow University for their appetite for hotdogs! We could not possibly have done it without you all.

# Contents

	Page
<b>1. Executive Summary Report</b>	
Background Information, Aims, Logistics and Finance	6-22
<hr/>	
Bolivia.....	7
The Beni Savannahs & Seasonally Flooded Llanos de Moxos.....	8-9
The Reserva Barba Azul.....	10-11
Biodiversity of the Reserve.....	11-13
Study Site.....	13-15
Expedition Aims and Objectives.....	15-16
Logistics.....	16-21
Financial Report.....	21-22
Forced Changes to Expedition objectives.....	22
<b>2. Savannah Passerine Study:</b>	
Abundance, Distribution & Microhabitat Preferences of Threatened Species	23-68
<hr/>	
Introduction.....	24-37
Aims.....	37-38
Methods.....	38-42
Results.....	43-54
Discussion.....	54-65
References.....	65-68
<b>3. Blue-Throated Macaw Study:</b>	
Minimum Population size, Movement and Habitat Use of Pre- roosting Blue-Throated Macaws	69-92
<hr/>	

Introduction.....	70-72
Aims.....	72-73
Methods.....	73-77
Results.....	77-87
Discussion.....	87-91
References.....	91-92

#### **4. Nightjar Survey:**

Nightjar diversity survey and the search for the endangered white-winged nightjar ( <i>Eleothreptus candicans</i> )	93-99
---	-------

---

Introduction.....	94
Aims.....	94
Methods.....	94
Results.....	95-98
Discussion.....	98-99
References.....	99

#### **5. Mammal Report:**

Minimum Abundances of Key Species and Diversity	100-112
---	---------

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Introduction.....	101
Methods.....	101-103
Results.....	103-110
Discussion.....	110-112
References.....	112

# 1. Executive Summary Report

## Background Information, Aims, Logistics and Finance

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**Figure 1.1:** *A view over the open grasslands of the Llanos de Moxos in the Beni Savannah Region of Northern Bolivia. Forest Islands on Alturas (high regions) are visible on the horizon.*

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Joanne Kingsbury

## Bolivia



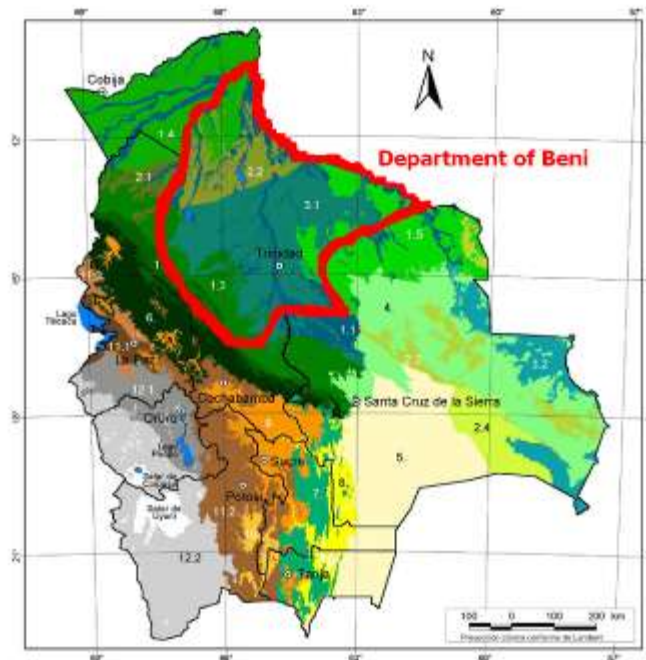
**Figure 1.2:** *Map of Bolivia in South America*

Spanning an area of 1,098,581km<sup>2</sup>, landlocked Bolivia is located at the heart of South America where it is bordered, to the north, by Brazil and Peru and, to the south, by Chile, Argentina and Paraguay (See Figure 1.2). Despite its modest size and lack of coastal and marine ecosystems, the country exhibits staggering geographical and climatic diversity (Hennessey et al 2010). Habitats extend from the extreme and chilly heights of the Andean altiplano where vast salt flats, snow capped peaks and unique dry valleys dominate the landscape, to the low laying humid tropical rain forests and scorched savannah grasslands typical of the southern Amazon Basin. Bolivia's biodiversity is equally rich and has earned it a well merited title as one of earths "megadiverse" countries (Ibisch 2005).

Containing around 14% (1378spp) of the world's bird species in an area equivalent to 0.75% of earth's terrestrial surface (Stattersfield *et al.* 1998), Bolivia is ranked fifth in the world in terms of its avian diversity (Hennessey et al 2010). Other biological attributes include 356 documented mammal species (Salazar-Bravo and Emmons 2003), 266 reptile species (Gonzales and Reichle 2003), and over 200 species of amphibian (Reichle 2003). Further, more than 20 000 plant species exist within its frontiers, ranking it around 10<sup>th</sup> place globally in terms of floristic diversity (Ibisch and Merida 2003). Together, these factors highlight the critical importance and global significance of conservation within Bolivia for preserving the earth's biodiversity.

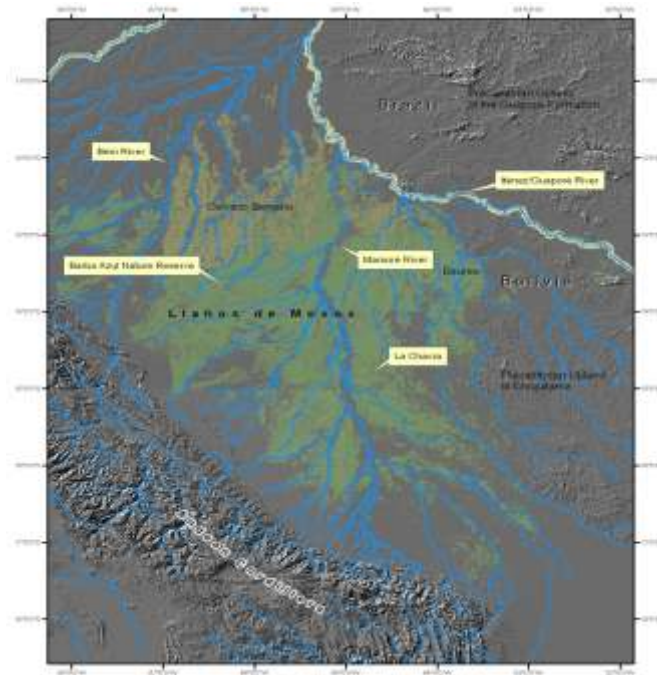
## The Beni Savannahs and Seasonally Flooded Llanos de Moxos Ecosystem

The Beni Savannahs are located in the tropical lowlands of northern Bolivia's Beni Department (See Figure 1.3) where they cover an area of around 160,000 km<sup>2</sup>. The ecosystem is endemic to Bolivia and considered critically endangered by The Nature Conservancy. Historically, a lack of technological advancement, coupled with reduced accessibility has afforded the preservation of an astonishing biodiversity in the remote Beni region (Ibisch 2005) with records including 509 bird species, 146 mammal species and more than 5000 plant species (Beck & Moraes 1997). However, considering the huge lack of research on the regions biota, there may still be much to uncover regarding its diversity (Langstroth (in press)). At present, almost all land in the Beni is privately ranched and no restrictions have been placed on purchasing property in the region. Additionally, the Beni savannas remain almost entirely unprotected. Although the impacts of ranching on the regions natural landscape are largely un-assessed (Langstroth (in press)), there is rising concern that the Beni's natural flora and fauna may be under increasing threat. The government has already ruled out the possibility of extending its network of national parks, (Ibisch *et al.* 2005) thus all further conservation effort is likely to take the form of private reserves.



Beni cerrado region (See Figure 1.4). The Beni cerrado is similar in composition to other Amazonian cerrados such as those of Brazil, appearing on stable upland regions and forested habitats occurring in lowland river valleys (Langstroth in press). The Llanos, characterized by its extensive seasonally flooded savannas, is notably different. Here, vegetation forms are inverted with grassland appearing in low lying seasonally inundated regions and forests forming on raised land (Langstroth (in press); Mayle *et al.* 2007).

The Llanos is the main constituent habitat of the Beni region, covering an area of around 126 000 km<sup>2</sup> (Langstroth (in press)). The plains are extremely flat with little variation in elevation, typically ranging from only 100 to 200 m above mean sea level. Mean annual temperatures range from 21-27°C and annual precipitation varies between 1100 – 2500 mm, with the majority falling in a distinctly long wet season between September and May (Navarro *et al.* 2002; Haase & Beck 1989). During this period, a substantial increase in discharge rate occurs in the Beni, Mamoré and Iténez rivers, as well as other associated tributaries which traverse the Llanos (Hamilton *et al.* 2004). This is a result of increased snowmelt in the upstream high Andes whose river systems drain into the region. Hampered by the lack of run-off in the flat basin, increased local precipitation and raised river levels combine to cause dramatic seasonal flooding across the plains. (Haase & Beck 1989; Beck & Moraes 1997; Hamilton *et al.* 2004) The level of this flooding is variable throughout the region but is generally less than 1m. (Hamilton *et al.* 2004).



**Figure 1.4:** Map of the Beni Department, showing the two major savanna- mosaic landscapes present; The Llanos de Moxos (green) and the Beni cerrado (brown). Map also displays the relative positions of the three main river systems of the region, The rivers: Ben; Mamoré and Itenez and the Reserva Barba Azul. From Lingstroth (in press)

## The Reserva Barba Azul

In 2008 the Bolivian Birdlife International partner, Association Armonia, facilitated the purchase of the 3558 hectare Reserva Barba Azul (RBA) creating the very first protected area within the Beni Savannah ecosystem.

The RBA, formally San Lorenzo Ranch (a fully operational ranch beef cattle ranch) was chiefly set up to protect one of the largest remaining wild populations of critically endangered blue-throated macaw (*Ara glaucouularis*). A species, endemic to the Beni Savannas and for which the reserve is named (Barba Azul meaning “blue beard” in Spanish - the local colloquial name for the species). The reserve was the first area ever to be set aside for the protection of this charismatic, endemic bird with a wild population estimated at no more than 300 individuals (Birdlife *et al* 2010b). The Macaws have since acted as a flagship for the RBA, attracting funding for its study, protection, management and expansion. Other threatened flora of the reserve have indirectly benefited from this arrangement being, quite literally, protected under the blue-throated macaws wing.

From the outset, Armonia have aimed to promote the regeneration of the reserves habitats back to a more natural state, largely through clearing the land of cattle, erecting new fences to keep cattle out and appointing a ranger to maintain and protect the reserves boundaries and to remove the herds that inevitably stray in from time to time. An extensive nest box project, erecting around 100 artificial nests, was completed in 2009, aimed at providing the BTM with more breeding space in a bid to reduce competition with other species for nesting cavities. Future plans for the BTM include building artificial palm islands within the savanna to allow greater roosting opportunity within the reserve area as many birds are known to overnight on the islands of a nearby, unprotected ranch where it is feared they may be susceptible to poaching for the pet trade and for their vibrant feathers.

Some of Armonias current aims for the reserve are: to maintain and improve protection of the reserve while continuing to monitor blue throated macaw populations; to promote biological research on other elements of the reserves flora and fauna with specific respect to vulnerable and threatened species; to expand the reserves area and implement a sustainable tourism project in order to help fund the reserves upkeep and, finally, to implement management strategies that will best preserve the reserves natural community as a whole.

Since its purchase, data collection on avifauna has ranked high in priority for Armonia but studies of mammalian, herpetological, ichthyological and botanical diversity are also considered integral to our understanding of the region. Local scientists, including Mauricio Herrera, Armonias’ chief conservation coordinator and Gustavo Sanchez, a leading Bolivian ornithologist from The Museo de Historia Natural Noel Kempff Mercado, have been involved with producing a comprehensive species list for the reserve. This list was added to by students from the University of Glasgow’s Exploration Society who, in 2009, conducted a biological inventory of flora and fauna within each of the different habitats of the reserve. Such studies have highlighted the presence of several

vulnerable and near threatened species using the reserve and also indicate the importance of the grassland habitat in particular for their presence.

## Biodiversity of the Reserve

**Birds:** Five hundred and nine bird species have been recorded in the Beni Savannah ecosystem (Beck, Moraes 1997). Research conducted last year during the 2009 Glasgow University Bolivia Expedition highlighted the importance of the Reserva Barba Azul not only for the blue-throated macaw but also for several other vulnerable and near threatened species (IUCN 2011), including the cock-tailed tyrant (*Alectrurus tricolor*), sharp-tailed tyrant (*Culicivora caudacuta*), black-masked finch (*Coryphaspiza melanotis*), dark-throated seed-eater; (*Sporophila ruficollis*) and greater rhea (***Rhea americana***) (Herrera & Mailard 2007; Reekie 2010). Findings from last years also include one potential observation of the Endangered white-winged nightjar (*Eleothreptus candicans*). However, confirmation of this sighting is still required. Other charismatic and more common elements of the avifauna include toco toucan (*Ramphastos toco*), blue and yellow macaw (*Ara ararauna*), peach fronted parakeet (*Aratinga aurea*), rosette spoonbill (*Ajaja ajaja*), common potoo (*Nyctibius griseus*) and red crested cardinal (*Paroaria coronata*) (See Figure 1.5).



**Figure 1.5:** Red-crested cardinal (*Paroaria coronata*)

**Mammals:** One hundred and forty six mammal species have been found to inhabit the Beni (Beck, Moraes 1997). The area shares many species with the Amazon rainforest

further north and also several with the neighbouring Gran Chaco grasslands to the west. During the 2009 Glasgow University Bolivia Expedition, jaguar and puma were found to be using the reserve. Presence of the near threatened (IUCN 2011) maned wolf (*Chrysocyon brachyurus*) was recorded via vocalisations on several occasions. Vulnerable (IUCN 2011) giant anteaters (*Myrmecophaga tridactyla*) and near threatened (IUCN 2011) pampas deer (*Ozotoceros bezoarticus*) were commonly encountered along transects and photographed on camera traps. Additionally, track surveys found some evidence for the presence of ocelot (*Leopardus pardalis*), margay (*Leopardus wiedii*) and pampas cat (*Leopardus colocolo*). More common elements of the mammalian fauna include abundant howler monkeys (*Alouatta caraya*) and at least two species of armadillo, numerous capybara (*Hydrochoerus hydrochaeris*), tamandua (*Tamandua tetradactyla*) (See Figure 1.6) and crab eating fox (*Cerdocyon thous*). It is also expected that the region will have a similarly diverse and distinct bat species assemblage, as we embark this year on the very first bat inventory conducted within the reserve.



**Figure 1.6:** Southern tamandua (*Tamandua tetradactyla*)

**Reptiles and Amphibians:** The reserve holds important populations of the declining black caiman as well as the endemic Beni Anaconda (*Eunectes beniensis*). Numerous more common species of lizard, snake and amphibian also exist within the reserve including the boa constrictor, common yacre caiman (*Caiman yacare*) (See Figure 1.7) and polka-dot tree-frog (*Hyla punctata*).



**Figure 1.7:** *Common yacare caiman (Caiman yacare)*

**Botanical:** As the foundation of any terrestrial habitat, plants are essential to the healthy functioning of an ecosystem at all trophic levels and the Beni savannahs are no exception. With 5000 plant species estimated, the Beni region is a botanical hotspot. However, very little is known of these abundant species particularly with respect to the grasses and it is thought probable that many may remain undiscovered.

## Study Site

**Reserve Overview:** The Reserva Barba Azul is located at the heart of the Llanos de Moxos floodplains in the west Mamoré river region, around 75km west of the town, Santa Ana de Yacuma (13°45'S, 66°07'W; Altitude 170m). The site, a 36km<sup>2</sup> (3558 hectare) section of the reserve formally managed as San Lorenzo Ranch, sits on the northern banks of the Rio Omi. There is no development within or around the reserve, with the exception of a few, small, neighboring estancias connected by dirt roads. Access is limited to four wheel drive vehicles and light aircraft, which can land on a small, rustic landing strip situated on a nearby ranch. Overland access is often only feasible during the dry season, with much of the region underwater and largely impassible during the wet season. The reserves habitats constitute a savannah-mosaic which includes forested habitats and wetland/riparian zones. The layout of the reserves major habitat features is indicated in figure 1.8 alongside the position of base camp.



**Figure 1.8:** Satellite map of the Reserva Barba Azul. Reserve boundary shown in red, Access trails in yellow and habitat features in blue. (Adapted from Google Maps (2010))

**Forested habitats:** Forest islands are present on Alturas (higher ground) and constitute around 15% of the reserves area. Small islands are scattered throughout the savannah, particularly concentrated within the wetland zone at the reserves northern limits (See Figure 1.9). The three largest islands, possibly remnants of ancient gallery forest (Mayle *et al* 2006), are found forming a chain like archipelago near the banks of the Rio Omi in the south of the reserve. The islands are dominated by palms, *Attalea phalerata*. Gallery forests are also present with two small sections hugging the banks of the Rio Omi in the extreme south-east and south-west of the reserve.

**Savannah habitats:** Savannah habitat covers around 80% of the reserves area. This exists along a continuum from the more densely wooded Cerradão (CD), present on the fringes of the main forest islands, through the progressively more open and gramanaciously dominated habitats of the Cerrado sensu lato (CSS), Campo Cerrado (CC) and Campo sujo (CS) which extend north from this fringe on a semi-altura (expanse of mid-elevation ground). These areas are not expected to be significantly inundated during the rainy season due to their altitude (Aquilino Molino, project botanist, personal comment). CSS, CC and CS features fall along a typical Cerrado gradient from CSS to CS in a topographic order typical of seasonally flooded savannahs: CSS on higher elevated ground near the main island, graduating to CS on lower ground (Langstroth in press). Seasonally flooded grasslands, similar structurally to the Brazilian Campo Limpo (CL) , are present in Bajios where annual rains and overflow from the Rio Omi cause flooding in the rainy season (Aquilino Molina Olivera, personal comment). This region will

henceforth be referred to as CL/SF. This mixed habitat extends north from the CC/CS grasslands until it is intercepted by wetlands at the northern limits of the reserve.

***Riparian and Wetland habitats:*** A small area of wetland habitat (WET) lies at the northern end of the reserve, consisting of damp and dry grasslands interspersed with several small forested islands (See Figure 3.2). Riparian and wetland zones also occur alongside the river in the south of the reserve. Water levels vary in each of these zones from year to year, probably depending on the intensity of the wet season and temperatures during the dry season with water levels tending to drop off as the dry season continues.



**Figure 1.9:** *View over the wetland grasslands at the northern limit of the Reserva Barba Azul.*

## 2010 Expedition Aims and Objectives

***Expedition Aims:*** The primary aim of this year's expedition was to conduct surveys of key avian and mammalian conservation species present in the Savannah habitat of the Barba Azul Reserve in Northern Bolivia. We aimed to determine and map the distribution of species in relation to the botanical structure and composition of the Savannah habitat. This was in order to allow assessment of the ecological importance of its microhabitats

for vulnerable and endangered species. We also aimed to produce population abundance estimates for key species as well as continuing with collection baseline inventory data for the mammalian fauna of the reserve. Our work was conducted alongside local Birdlife international partner Association Armonia and local scientists and students to assist us with field methodologies and data collection.

***Expedition Objectives:*** In order to achieve the expedition aims, the following objectives were set:

- 1 Map roost site distribution and conduct roost site population counts for the critically endangered blue-throated macaw in order to assess the population size of individuals using the reserve and also to assess roosting behavior.
- 2 Conduct territory mapping of the cocktailed tyrant, sharp tailed tyrant, black-masked finch & wedge tailed grass finch via colored ringing and Line transects in order to assess habitat use and species distribution.
- 3 Establish estimates of population density and distribution for the vulnerable cocktailed tyrant, sharp tailed tyrant, black-masked finch and greater rhea via distance sampling along line transects. Also to conduct assessments of habitat use via botanical assessments.
- 4 Establish if the endangered white winged nightjar is present on the reserve via night-time visual encounter surveys (VES) and mist netting and, if so, map its distribution in the savannah via nocturnal line transects. Also to conduct assessments of habitat use via botanical assessments.
- 5 Establish abundance indices for the vulnerable and near-threatened mammal species within the reserve including giant anteater, maned wolf and pampas deer using camera trap surveys, track trap surveys, and line transects to calculate encounter rates.
- 6 Conduct the first assessment of bat species diversity in the reserve in order to gain baseline data for future studies. This involved mist netting and identification working alongside a Bolivian expert.
- 7 Conduct botanical surveys of savannah structure and composition that will contribute towards investigation of the habitat use and preferences of earmarked avian species.

## **Logistics**

***Planning research:*** The research aims and objectives were selected with respect to the current research goals of Armonia for the reserve and developed in Scotland with the help of Dr Ross Macleod. Dr Macleod also helped us to plan the methodology we would use

to achieve these aims and other logistical aspects of the expedition. Further, the planning of botanical surveys was assisted by Dr Kevin Murphy.

***Fundraising:*** Team members all worked extraordinarily hard to raise funds over the academic year. Money making endeavors included several cold nights selling hot dogs to the obliging patrons of the Queen Margaret Union, bucket rattling on the streets of Glasgow and hosting various themed evenings including pub quizzes band nights and movie nights. These events were very successful, contributing around £3000 to expedition funds. The expedition also applied for the support of several charitable trusts whose financial assistance was essential to the success of the expedition and to whom we owe a great depth of gratitude. Additionally, each student made a personal contribution of £750 towards . Combined, the money from these sources enabled the expedition to successfully achieve its target of £16 000.

***Timetable of Travel:*** The expedition team traveled from Glasgow to Bolivia on July 15<sup>th</sup> arriving on July 16<sup>th</sup>. In total, the duration of the expedition was 8 weeks and 3 days, with members flying home on September 14<sup>th</sup>. Following our arrival, just over one week was spent in the bustling lowland city of Santa Cruz de la Sierra where our accommodation took the form of a small, locally run, inexpensive hostel used by previous expeditions. During this period, any expensive expedition equipment was stored at Armonia for safe keeping.

Time spent in Santa Cruz allowed team members to acclimatise and also provided time to purchase non-food supplies for the expedition (batteries, stationary, protective clothing etc). Further, it provided both the opportunity for the team to meet the local scientists and students with whom we would work as well as giving leaders the time to train expedition members in equipment use & field techniques at Armonias head office. On July 24<sup>th</sup>, the expedition traveled North of Santa Cruz to the capital town of the Beni department, Trinidad. A four-wheel drive vehicle and driver was supplied by Armonia to transport expedition equipment and team members. However, due to team size, several students and scientists also had to take an overnight bus to Trinidad. Following this, one night was spent in basic accommodation at Armonias offices here before the team traveled onwards to the small village of Santa Anna de Yacuma the following day. Here, team leaders collected sufficient food supplies to last the expedition 10 days. These were purchased from local markets before driving on to the reserve the same afternoon. An additional four wheel drive truck was also hired here so that the whole team and all expedition food and equipment could be transported to the reserve simultaneously. A total of 6 weeks were spent in the reserve conducting research. Our return journey on September 7<sup>th</sup> used the same route and transport and we arrived back in Trinidad on the September 9<sup>th</sup>. From the 9<sup>th</sup> – 12<sup>th</sup> data were transcribed and recorded to databases at Armonia head office in Santa Cruz.

***Timetable of Survey Work:*** During the first week of the expedition, time was spent mist netting in order to try to achieve the colour ringing of a sufficient number of survey birds to allow territory mapping. One or two team members worked alongside the ornithologist to achieve this starting at first light and continuing until around 09:30h/10:00h after

which time it became too hot to have birds in the nets. One team of two people spent the first 4 days erecting camera traps in predetermined areas around the reserve and checking that each of these was functioning correctly. This work began at first light and continued until around 11:00h, starting again at around 16:00h and continuing till just before sunset. Once camera traps were erected the team began thrice weekly nocturnal avian and mammalian transects usually starting around nightfall and continuing through to around 20:00. These were continued for the duration of the expedition.

Time was also spent in the first week selecting and marking out the positions of savannah line transects as well as visiting and choosing islands for the blue-throated macaw roost site surveys. Once completed, savannah line-transects and botanical sampling were conducted by one or two teams of two people daily beginning at first light and continuing through to around 10:30h. Additionally, one team of two people conducted roost site surveys at each island once per week starting one and a half hours before first light and continuing until sunset.

During weeks 1-3, one person also assisted the expedition mammologist in conducting evening bat mist netting from 21:00h till 02:00h. Similarly, in weeks 4-5, one person assisted the expedition botanist in conducting his collections within the grasslands. Point counts of the blue throated macaw were also implemented early in week 3 as data from roost site surveys seemed to be limited. These were then conducted 3 times a week from around 16:30h till sunset.

It should be noted that all members of the expedition were given the opportunity to work on each expedition project.

***Training:*** The data collection for our studies was carried out by a team of 7 Glasgow University biology students and one Bolivian student from the University of Santa Cruz alongside four trained Bolivian scientists including an ornithologist, mammologist and botanist. Training in both botanical collection and bat and bird netting was provided in the field by the latter. While, in an attempt to mitigate error arising from inexperience, training sessions were also conducted prior to the surveys by either Dr Ross Macleod, myself or co-leader Duncan McNeil to introduce field workers to equipment, survey birds, terrain, local environmental conditions and data collection methods. Direct training involved: an introduction to GPS receivers and their use for navigation, measuring distances and marking waypoints; an introduction to camera trap set up and optimal positioning/placement; an introduction to optical equipment including binoculars and telescopes; a morning of bird watching at the survey site, with an introduction to the location and identification of target birds and an oral session describing field methodologies and the standardizing of habitat data collection. In addition, a run through savannah and evening line transect was conducted by myself and one team member to assess the feasibility of walking distances, timing and data collection. This meant that at the start of these surveys there were two experienced individuals that could be paired with and supervise those who had not yet conducted a full line transect with data collection.

***Field Accommodation and Supplies:*** Accommodation was on site in tents. In addition to personal tents, two large research tents and a basic wooden lean-to cabin were available as workspace and were used daily as makeshift laboratories. There was also a basic kitchen building with a gas stove, storage space for food and seating. We also had a separate drop toilet and washing area. All water for drinking and sanitation came from the well located within the camp. Due to this being a particularly dry year, drinking water also had to be sourced and purified with iodine from the nearby Rio Omi.

Most expedition food was purchased from local supermarkets in Santa Anna de Yacuma and transported to the field site via four wheel drive on a weekly basis. We also had the ability to supplement these purchases with fresh meat, fruit and vegetables sold to us by nearby cattle ranches.

***Equipment:*** The expedition carried 4 Garmin E-Trex GPS systems, 16 digital still camera traps, one Satellite telephone, one wildlife hide and two telescopes with tripods, all brought in and transported from the U.K. Both team leaders had extensive experience of using all of the above on previous Glasgow University expeditions to Bolivia and Ecuador. Mist nets and metal and cellulose color rings for bird ringing were provided by Bolivian scientists via Armonia. Students were provided with an equipment list prior to leaving the U.K. and provided their own torches and binoculars etc

***Personnel:***



**Figure 1.10:** *The 2010 Glasgow University students.*

**Dr Ross Macleod** – A veteran of many previous expeditions to Bolivia, Ross provided the scientific know-how and technical support, which were invaluable to the success of

this expedition. He also managed to turn a team of frog loving, caiman hunting, snake enthusiasts into a bunch of avid bird watchers.

**Joanne Kingsbury** - Jo was definitely the boss about camp and crossing her usually resulted in a swift kick, to be fair though this was always followed by a long and humble apology. But in the end Jo was almost definitely was the best asset the team had, always hard working and up for a challenge. Jo always had an innovative solution for every problem, and even perfected the human catapult as a means to collect water from the river.

**Duncan McNeil** – The only man who could sleep through a horse trying to get frisky with his tent. Duncan managed to get a tic in just about every conceivable bodily location and was a dab hand at rescuing the ladies from snakes, scorpions and rainstorms. He bravely ate most of the dulce de letche so that the other team members didn't have to and is also the one of the only individuals I know (apart from gwynedd) that would walk towards a suspiciously jaguar-like roaring noise in a bush to “get a better look”.

**Lydia Bach** – There's nothing like a bit of German efficiency to get your expedition in order and Lydia is a dab hand at pretty much everything. However, boiling piranha heads for their skull bones is a little bit weird but I suppose that's what you get when you invite a marine and freshwater biologist onto your expedition! The first of all of us to get a scorpion in their tent, she dealt with it well, the screams were only heard faintly in neighboring Brazil.

**Kirsty Godsman** – “Queen of the Night(jars)” and the strongest member of the expedition, Kirsty could probably remove a lid even if it had been welded to the top of a jam jar. Coupled with this, her inherent determination and inability to give up in the face of all things that are almost impossible (including tasks such as crossing a field of worm mounds at midday while still enjoying and remaining positive about botany) is remarkable.

**Christopher Long** – AKA “Eyes” Chris could do a where's Wally from 20 paces with your grandmothers spectacles on back to front, a skill that made him a useful chap for finding small brown birds against big brown backgrounds (perfect for the savannah). Apparently allergic to water, Chris holds the record for the longest period without washing in the reserve but smelt surprisingly fresh.

**Alwyn McKenna** – AKA “The princess of Scotland”, a useful girl to have along on an expedition as if you run out of supplies as you can sell her to local ranchers as a wife in exchange for food. Never, ever consider laughing at this girl whilst she's cooking as there is a very strong chance you will be beaten to death with a ladle. We hope that following this trip, Alwyn will always remember to reset her watch after flying through the Bermuda Triangle.

**Gwynedd O'Neil** – Gwynedd was often the cheeriest person in camp, and always out for a bit of an adventure, even if that meant getting her slippers a bit muddy chasing jaguars

into the bushes. But despite her happy go lucky attitude she was probably one of the most resourceful people in camp and when adversity struck she could usually be seen whipping off her shirt wrapping it round her head and sparking up a fag before powering on.

**Aquilino Molina Olivera** – Expedition botanist, Aquilino worked like an ox in the sweltering heat of the savannah to get the data we needed. He never gave up, even when the biscuits ran out, the water was hotter than tea and we were forced to eat spam with our bare hands.

**Luis Hernan Acosta Salvatierra** – Expedition Mammologist, Luis was one of the only Bolivian men we met on the trip that really believed in equality. Unlike the others, he was quite happy to let the girls carry the heavy stuff! The team will never forget those long dark nights’ playing cards, pulling dung beetles out of mist nets and listening to Shakira!!

**Miguel Angel Aponte Justiniano** – Expedition ornithologist, Miguel quickly succeeded in winning our hearts by cooking the best fried eggs in Bolivia and won’t be forgotten for teaching us the ins and outs of sneaking up on a pootoo.

**Francisco Morezapiri** – Bolivian Student and mammology assistant, Francisco was also known as “The Cabbage” due to his ferocious and unrelenting appetite for this tasty and versatile vegetable.

## Financial Report

The projected cost of the expedition plus a 10% contingency was £ 16,560. Personal contributions were set at £ 750 per student, providing a total of £ 5,250 and £ 11,310 to be raised through fundraising.

### *Projected Costs*

£

Flights: London – Santa Cruz	5950
Administration Costs	250
Training Courses	510
Equipment	2700
Insurance	1000
Food	1120
Accommodation	675
Transport	1000
Wages	1300
Post-expedition	550
Contingency (10%)	1505
<b>Total</b>	<b>16560</b>

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### ***Expedition Income***

£

Personal Contributions	5250
Grant: University of Glasgow	1400
Grant: Royal Geographical Society	1000
Grant: Royal Scottish Geographical Society	400
Grant: Carnegie Trust	2000
Grant: Glasgow Natural History Society	700
Grant: Thriplow Charitable Trust	2000
Grant: Gilchrist Educational Trust	1000
Grant: Chester Zoo Studentship	500
Fundraising Activities	1800
<b>Total</b>	<b>16000</b>

### ***Expedition Expenditure***

£

Flights	7000
Food	1500
Wages	2000
Accommodation	300
Transport (including internal flights for botanist)	1200
Medical kit and first aid course	300
Equipment (Camera Traps/protective clothing/batteries/camp fuel costs etc)	3000
Post-Expedition Costs (report write up/printing/translation)	600
<b>Total</b>	<b>15 700</b>
<b>Balance surplus:</b>	<b>300</b>

After contingency we expected a budget shortfall of around £560. However, we ended up with a budget surplus of £300 which suggests our estimation of the budget based on previous expeditions to Bolivia was fairly accurate. The way we spent the money differed from our estimations in that flights were considerably more expensive than expected. Also food costs were higher than in previous years as we also had additional student assistants and guides to feed. However accommodation costs were low and insurance was provided by the students individually so we managed to save money here. The surplus money will be used to contribute towards the follow up expedition which is planned for summer 2011.

## **Forced Changes to Expedition Objectives**

*Territory mapping of vulnerable passerines:* Despite multiple attempts at netting target species, only a total of two survey birds were captured in the first week. We were therefore unable to conduct this side of the passerine survey.

## 2. Savannah Passerine Study: Abundance, Distribution & Microhabitat Preferences of Threatened Species

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Joanne Kingsbury

## Abstract:

This study examined the population size, distribution and microhabitat preferences of three key conservation species of grassland bird within an area of seasonally flooded Bolivian savannah in the protected Reserva Barba Azul. Target species were: the cock-tailed tyrant, *Alectrurus tricolor*; the black-masked finch, *Coryphaspiza melanotis* and the wedge-tailed grass finch, *Emberizoides herbicola*. The former two, globally threatened birds of which little is known and the latter, a more common and widespread indicator species for healthy savannah ecosystems.

Surveys were conducted by line transect sampling methods in four grassland zones largely comparable in vegetative composition to habitats of the Brazilian Cerrado sensu lato, including areas similar to: Campo limpo, Campo sujo, Campo cerrado and Cerrado sensu stricto. A total of 191 target species observations were made over 57.2km<sup>2</sup> of transect including 89 wedge-tail grass finch sightings, 79 black-masked finch sightings and 23 cock-tailed tyrant sightings. Habitat data was collected for each bird along side random habitat data for the grassland area. Distance sampling was used to assess population size and distribution patterns for each species and TWINSpan multivariate analysis to integrate bird and habitat data.

The results indicated that populations of approximately 427 cock-tailed tyrant, 768 black-masked finch and 750 wedge-tailed grass finch currently use the reserve. The cock-tailed tyrant appeared to be habitat restricted, occurring in only two of four study zones. Conversely, the black-masked finch and wedge-tailed grass finch appeared to be less habitat restricted, occurring in all four study zones. Cock-tailed tyrants appear to prefer areas of very tall grass where bushes are absent and worm mounds are present. Both the black-masked finch and wedge-tailed grass finch seem to prefer areas where non-grass species are fruiting, seeding or flowering and grass is moderately tall.

## 2.1. Introduction:

### What is a Savannah?

Eiten (1972) describes the use of the term savannah as “much abused” and it would appear that this situation has improved little in almost 40 years as the terms, “savannah” “tropical grassland” and “grassland” are often used interchangeably in the literature. It is therefore important to define these terms as they will be used in this text: the use of the term “savannah” will follow the definition of Sarmiento (1984) “An ecosystem of the warm tropical lowlands, dominated by herbaceous cover which shows clear seasonality in development with a period of low activity related to water stress and where fire is a frequent, natural reoccurring event. The vegetation compliment includes both grassy and woody species such as shrubs, trees and palms, but these never form continuous cover

that parallels the grass”; “Tropical grassland” will be used in the sense of Osborne (2000). “Any ecosystem of tropics dominated by graminaceous (grass-like) vegetation, including not only purely herbaceous communities but also the mixed grass and tree communities of savannah”; further the term “grassland” will be used to describe any habitat within a savannah where tree cover does not exceed 15% and “savannah-mosaic” for any ecosystem in which savannah is the dominant physiognomy but other vegetation types also occur.

## **The Dynamic Savannah**

Often referred to as “non-equilibrium” environments, savannahs are dynamic ecosystems in which complex ecological processes have a varied consequence to vegetation composition. The relative abundance of grassy and wooded vegetation is highly heterogeneous in both space and time and varies greatly at global and regional scales (Sarmiento 1984). Such distribution of vegetation is shaped by plant tolerance to abiotic stresses and also by natural, abiotic and biotic disturbance processes (Scholes & Archer 1997). Plant available moisture and plant available nutrients are regarded as the primary stress factors which determine vegetation distribution across savannah landscapes. However, regional patterns in vegetation depend a great deal on site characteristics and local conditions including variation in climate, hydrological cycles; topography and soil properties. (Scholes & Archer 1997; Osborne 2000; Mayle *et al.* 2007; Langstroth (in press)). Natural disturbances such as fire and herbivory may be “superimposed” upon these as further modifiers of ecosystem structure (Price *et al.* 2010).

Fire is a regular and natural disturbance process which occurs in savannah ecosystems and many organisms which exist in savannahs have life history traits adapted to allow their survival in such an event (Bond & Keeley 2005; Eiten 1972). Natural ignition most frequently results from lightning storms in the drier portions of the year (Bond & Keeley 2005) but changing land use in recent decades, especially for agricultural purposes, has led to increased levels of human mediated burning within savannah landscapes (Pennington *et al.* 2006). Regular burning actively reduces woody biomass (Bond *et al.* 2004) while the suppression of fire disturbance increases wooded plant density and leads to “woody encroachment”, a natural form of succession where wooded biomass increases at the expense of grass biomass (Bond *et al.* 2004; Scholes and Archer 1997) Bond *et al.* (2004) used the Sheffield Dynamic Global Vegetation Model to assess the importance of fire as a determinant of biome distribution. The model predicted forest biomass to almost double in the absence of fire. Thus variation in fire regimes, for example as a result of anthropogenic influence, could lead to significant shifts in ecosystem structure within savannahs (Bond & Keeley 2005).

Herbivory may also greatly modify plant distribution. Herbivores actively remove biomass from savannah systems, but unlike fire, this process tends to be selective (Bond and Keeley 2005). Thus interactions between grazing patterns and savannah structure are considerably more complex. South American systems lack the abundant populations of large grazing mammals found in the African savannahs. Here, invertebrates are thought to play the vital role of primary consumers (Costa *et al.* 2008). Grasshoppers are

considered to be the dominant invertebrate herbivores in open savannah grasslands (Andersen and Lonsdale 1990) while empirical evidence suggests that leaf cutter ants may be of considerable importance for modifying more wooded savannah regions (Costa *et al.* 2008).

The effects of fire and herbivory may also interact to shape relative vegetation composition. Fuhlendorf *et al.* (2006) found the effects of patch burning were accentuated by grazing of native herbivores in North American temperate prairie. Patch burned areas were preferentially grazed, acting to increase bare ground area. Conversely, grazers avoided non patch burned areas leading to litter build up and domination of tall-grass prairie.

Seasonality is a more distinctive and fixed feature of savannah systems. All have cyclic, annual wet and dry seasons owing to their location in either of two highly seasonal Köppen climatic zones, the (Aw) tropical savanna region or (Am) tropical monsoon region. These zones and the savannahs they encompass are typified by high mean annual temperatures (18-30°C) and moderate annual precipitation (250-2000mm) with the majority falling in the wet season. However, the extent, timing and duration of rainfall are still locally variable. (Cole 1986; Sarmiento 1984; Mistry 2000; Scholes & Archer 1997).

## **The Importance of Savannah Ecosystems for Birds**

The savannah biome is extraordinarily extensive, covering an estimated 23 million km<sup>2</sup> (Cole 1986; Bond & Parr 2010). Collectively, it forms the largest terrestrial biome of the tropics, cloaking more than 50% of the vast African and Australian continents, 45% of South America and 10% of both South East Asia and India (Scholes and Archer 1997; Cole 1986). Considering their global significance in terms of size and despite their moderate levels of  $\alpha$ -diversity (within habitat species diversity) compared with tropical forest systems (Stotz *et al.* 1996), savannahs are now considered significant reservoirs of global biodiversity (Price *et al.* 2010; Bond & Parr 2010). Indeed, if tropical forests are disregarded, savannahs, tropical grasslands and shrub-land combine to form the most specious global ecosystems in terms of their avian diversity (Baillie *et al.* 2004; Stattersfield *et al.* 2000). Based on searches of Birdlife International's databases (Birdlife 2010a), the African savannahs are the most diverse of these systems overall with 1419 species, followed by those of South America, Asia then Australia which harbor 880, 840 and 501 species respectively.

Open grassland habitats are particularly important and contain a biota which is considered unique and distinct (Bond & Parr 2010; Stotz *et al.* 1996), not merely a derived subset of forest or savannah-woodland species (Bond & Parr 2010). Taking South American savannahs as an example, Stotz *et al.* (1996) found that a substantial proportion of the avian species which utilize open grasslands do not use any other habitats (25%) and of those that do, an even greater proportion (75%) still rely on them as their primary habitat. From the Cerrados of Brazil, Silva and Bates (2002) reported evidence to support this, with 27% of Cerrado birds entirely restricted to open habitats.

Further, while Stotz *et al.* (1997) considered sub-habitat specialization to be rare in South American grassland birds, Tubelis & Calvalcanti (2001) found evidence for specialization in the grassland birds of Brazil's Cerrado region with 33% of all grassland species restricted to just one type of campo grassland habitat. These studies emphasize the importance of grasslands for many bird species, some of which could survive nowhere else on earth.

## Current Status & Threats to Neotropical Tropical Grasslands

Historically, savannas have suffered great devastation as a result of changing land use and habitat destruction for Agriculture (Pennington *et al.* 1997) with many extensively converted to croplands, plantations or rangelands for livestock (Bond and Parr 2010). A recent study suggested that increased agricultural intensity is still a major threat faced by tropical grasslands. Jarvis (2010) reported that tropical grasslands were the most urgently threatened ecosystems on the South American continent with respect to multiple, current, anthropogenic trends including increasing: fire frequency, grazing pressure, rates of conversion to agriculture and ease of accessibility (Jarvis 2010).



**Figure 2.1:** Cattle grazing in the grasslands of the Reserva Barba Azul in Northern Bolivia. These individuals, from a neighboring estancia, had found their way into the reserve through a broken fence

Traditionally, the open savannahs of South America have been utilized by humans for ranging cattle (See Figure 2.1). Their typically nutrient poor and acidic soils (Collar *et al.* 1997; Cavalcanti 1988) along with considerable restrictions to access (Ratter *et al.* 1997), deeming them largely unsuitable for cropping. Prior to around 50 years ago, ranching of the Brazilian Cerrados occurred in natural landscapes at relatively low density, a system considered by Ratter *et al.* (1997) to be, to some extent, environmentally friendly and sustainable. However, the 1960's saw drastic changes in land use patterns with processes, such as soil liming and fertilization taming soils and allowing arable farming considerably more success (Collar *et al.* 1997; Cavalcanti 1988).

More recently, agricultural subsidies introduced by the Brazilian government have continued to drive change in the region, providing the money and means to open new roads and purchase modern agricultural machinery. Recent estimates suggest losses of total natural land area to have fallen by between 40-80% (Bond and Parr 2010) with a massive 25% of campo grasslands estimated to have been converted for agriculture between 1970 and 1996 alone (Bilenca and Minarro 2004 in Bond and Parr 2010). Soybean, sugarcane and citrus crops are amongst the cash crops now widely grown across these new agricultural frontiers (Stotz *et al.* 1996) and paper plantation "afforestation" projects for exotic pine and eucalyptus trees are regular features of the landscape (Bond and Parr 2010).

In the savannahs of northern Bolivia, cattle ranching has also been a widespread and common practice for centuries (Langstroth (in press.)) but cropping and plantation agriculture still appear to be largely excluded from the region, probably due to its prevalent inaccessibility and the considerable extent of land area which is underwater for large proportions of the year. As Langstroth (in press.) noted, there is little literary reference as to the impacts and intensity of cattle grazing on this region. However, Jarvis (2010) reported that increased overgrazing pressure was one of the primary threats currently facing the flooded savannah systems of South America. Additionally, accessibility into the region is also noted to be improving (Langstroth (in press.)). This is apparent even over two years of study in the region, with several new bridges cropping up along the Santa Cruz-Trinidad route over this period (personal comment). Thus the potential future threats to this region may be considerable.

## **Importance for Neotropical Savannahs for Avian Diversity**

The Neotropics are the planet's richest bio-geographic region in terms of their avian diversity (Baillie *et al.* 2004), with an estimated 40% (3808) of global species (Collar *et al.* 1997). They also contain the largest proportion of globally threatened birds, with 430 species of status vulnerable or higher (Baillie *et al.* 2004). Although the majority of threatened species are found in forested habitats, Neotropical savannahs are also considered of critical importance to many threatened birds.

An assessment of threatened birds of the Americas found that, at the time of study, 10% of Neotropical species considered globally threatened, were confined to grassland

habitats and that grasslands contained more than double the threatened species of any other non-forested habitat, including marine and freshwater zones (Collar *et al.* 1997). Concluding that such Neotropical Grasslands were “emerging as a major conservation issue”, Collar *et al.* (1997) proposed urgent action to conserve vast tracts of this habitat before even greater declines occurred and considered site conservation of primary importance for conserving the threatened species in question. More recent figures continue to suggest similar importance for Neotropical savannahs as habitats for threatened birds. Birdlife International currently list 9% of South American tropical grassland & savannah species as globally threatened\* These figures are comparable with Australasian and Asian tropical grassland and savannah birds, of which 9% (47 of 501spp) and 8% (104 of 840spp) respectively are threatened but are considerably higher than those of Africa, where only 5% (77 of 1419spp) are considered to be under threat. (Data from Birdlife 2010a)

The seasonally flooded savannahs of the Llanos de Moxos may hold some of the most important grassland systems on the South American continent in terms of their avian diversity. In a review of the diversity of Neotropical breeding birds, Stotz *et al.* (1996) defined 41 principal avian habitats based on vegetation type. Seasonally flooded savannahs, including those of Bolivia, were found to be the richest of all South American savannah grasslands in terms of their avian diversity with 103 bird species using them. The open campo grasslands of the Brazilian Cerrados had comparatively less species; 68. Additionally, seasonally flooded grassland had a similar number of grassland restricted birds to the Cerrado region (15 in Campo grasslands and 12 in seasonally flooded grassland) and a considerably higher proportion of birds using it as their primary habitat (34% in Campo grasslands and 56% in SF grassland). Despite the fact that Brazil's Cerrado avifauna is normally considered significantly more diverse, it would appear that seasonally flooded systems surpass it in terms of grassland bird diversity.

The savannahs of this region were also considered of significant importance for avian diversity by Collar *et al.* (1997) who commented that many of the grassland species of the Brazilian Cerrado would be considered threatened were it not for their largely intact populations in Northern Bolivia. However, much can change in 20 years and reassessment of the status of many Bolivian grassland birds would probably be needed to confirm whether Collar's statement still stands.

## **The Brazilian Cerrado Biome**

Although the savannahs of the Brazilian Cerrado are not seasonally flooded and very different in many respects to those which are (Langstroth (in press.)), some of the region's landscape components are similar and thus relevant to the habitat under study in this paper. For this reason it is useful to provide a brief summary of relevant information on the Cerrado region.

The landscape of the Cerrado biome is a complex and patchy savannah-mosaic which includes gallery/riparian forests and tropical dry deciduous/semi-deciduous forest. The dominant vegetation type throughout the region is a matrix of grassland and dry cerrado

woodland, termed the “Cerrado *sensu lato*” (CSL) (Ratter *et al.* 2006) with grasslands the most extensive habitat overall, 72% (Silva *et al.* 2002). The CSL exists as a continuum of vegetation types ranging from completely open grassland to almost completely closed woodland. It is generally accepted that the CSL can be divided into five separate sub-habitats along this gradient, each of which may be defined in terms of the structure, composition and relative dominance of woody and grassy vegetation. (Ratter *et al.* 2006; Silva *et al.* 2002; Ribeiro *et al.* 1983 as reported in Tubelis and Calvalcanti 2001; Eiten 1972) Authors’ definitions of these sub-habitats are generally similar with only small variations (See Table 2.1).

Habitat Type	Habitat Definition
<b>Campo limpo (CL):</b>	Meaning “clean field”, grassland with occasional shrubs that do not grow taller than the surrounding vegetation and in which tall woody plants are completely absent (Ratter <i>et al.</i> 2006; Eiten 1972)
<b>Campo sujo (CS):</b>	Meaning “dirty field”, grassland with scattered shrubs and occasional small trees that do not exceed 2% cover (Ratter <i>et al.</i> 2006; Sarmiento 1983; Ribeiro <i>et al.</i> 1983 as reported in Tubelis and Calvalcanti 2001)
<b>Campo Cerrado (CC):</b>	Meaning “closed field”, grassland with more conspicuous shrubs and trees, generally ranging from 2-5m in height and not exceeding 15% cover (Ratter <i>et al.</i> 2006; Sarmiento 1983; Ribeiro <i>et al.</i> 1983 as reported in Tubelis and Calvalcanti 2001)
<b>Cerrado sensu stricto (CSS):</b>	Meaning “closed in restricted sense” more wooded grassland with trees generally ranging from 3-8m in height and not exceeding 30% cover (Ratter <i>et al.</i> 2006; Eiten 1972)
<b>Cerradão (CD):</b>	A denser woodland made up of trees ranging from 8-13m high, casting considerable shade so that ground vegetation is sparse (Ratter <i>et al.</i> 2006)

**Table 2.1:** *Definitions of Cerrado sensu lato vegetation types of the Brazilian Cerrado including abbreviations.*

The landscape of the cerrado biome is undulating, and consists of a series of plateaus (elevations greater than 500m) and depressions (elevations less than 500m) CSL vegetation dominates on upland plateaus while depressions contain a mosaic of habitats (Silva *et al.* 2002). CSL tends to be restricted to well drained soils which are generally nutrient poor (Pennington *et al.* 2006). Other elements such as gallery forests appear in moister areas surrounding rivers and seasonally dry tropical forests appear in areas where soil nutrient content is higher (Ratter *et al.* 2006).

Haase & Beck 1989 and Langstroth (in press), share the view that the Llanos have distinctive vegetation form and generally agree on the importance of several factors which influence the regions vegetative ecology: The spatial distribution and composition of vegetation is primarily determined by seasonal inundation patterns and local micro-topography, as well as by plant tolerances to anoxic waterlogged soils during the wet season and desiccation/access to soil water during the dry. As a result of the regions inherent flatness, marginal differences in elevation can have significant effects on inundation patterns and therefore greatly determine the type of floral community capable of existing in a specific area. (Langstroth (in press))



**Figure 2.2:** A semi-altura region within the Reserva Barba Azul. Taken from the edge of the Cerrado *sensu stricto* (just visible at the right of the photo). Looking out over part of the Campo cerrado/Campo sujo habitat.

Flat, low-lying regions “Bajios” can remain flooded for several months during the wet season, completely hindering tree growth and leading to formation of open grasslands scattered with small shrubs and bushes (Haase & Beck 1989 and Langstroth (in press)). These may be likened in form to the non-seasonally flooded CL’s of the cerrado biome described previously (personal comment). In raised areas, “Alturas” that escape flooding, tree colonization can be supported and forested islands or “Islas” form (See figures 1.3 and 3.2). These may range in size from just a few, to hundreds of m<sup>2</sup>. (Langstroth (in press)) At intermediate elevations, “semi-alturas” vegetation structure and composition is variable and highly dependant on the extent of fire and grazing. Langstroth (in press)) . Heavily grazed semi-alturas or those exposed to frequent burning are more likely to consist of grassier flora where as those unaffected by such disturbance, succession of cerrado woodland occurs. (Langstroth (in press)) Cerrados, where present, often exist along elevational gradients, forming a transitional zone between Islas and Bajios incorporating areas that can be likened to CSS, CS and CC (Langstroth (in press)). Wetlands and gallery forests are also important features of the Llanos. (Haase & Beck 1989; Langstroth (in press))

## **Protected Areas & Management Priorities:**

The idealistic view that nature is best protected when left well alone is now largely redundant in conservation biology. Habitats are seldom pristine and the extent of anthropogenic modification to landscapes is such that natural ecosystem processes are frequently grossly altered or often lost altogether. (Primack 2006). In reality, the vast majority of protected areas occur as small, dislocated fragments of once expansive ecosystems, enclosed by agricultural or otherwise human-altered land. As such, they present a glut of problems to their resident wildlife including: restricted range sizes, genetic isolation, dispersal barriers and ease of human accessibility. (Ausden *et al.* 2004).

Isolation can also seriously modify the incidence and severity of natural disturbance processes on the landscape. Fires, floods and storms may occur at inappropriate frequency as ecosystem buffers which normally mediate their occurrence may be absent or dramatically altered by humans. If and when they do take place, such events are inclined to be proportionally more destructive than they would be in natural systems. (Ausden *et al.* 2004).

A growing number of biologists now agree that protected areas require some level of direct management and that the development and implementation of efficient and effective management strategies is essential for wildlife conservation within these areas (Price *et al* 2010; Skowno & Bond 2003; Margules & Pressey 2000; IUCN 2008/SSC). It is recognized that strategies used within reserves should be dictated by well thought out conservation goals which focus on improving the long term prospects of key elements of the biota (IUCN/SCC 2008; Margules & Pressey 2001; Sutherland 2000).

If the goal is thus to focus on protecting or improving populations of particular bird species present within a reserve, there must be consideration of how best to achieve this. The focus of management directives should, clearly, be purposely tailored to site specific

characteristics (Margules & Pressey 2001). For example taking into account both the presence of specific target conservation species and the state of their available habitat. As conservationists, understanding the biogeography and underlying ecology of a habitat is of great importance when considering management strategies for the protection of any of its species (Silva *et al.* 2002; Price *et al.* 2010) as is knowledge of the interactions which occur between such species and their habitat (Price *et al.* 2010).

Birds depend on healthy functioning ecosystems for their survival (IUCN/SCC 2008) so designing conservation strategies needs to account for their particular habitat requirements. Currently there are huge gaps in knowledge with regard to the precise habitat requirements of many birds and this is especially true for those considered most at threat (Stattersfield *et al.* 1998). For many, there is also general lack of reliable baseline data (Stattersfield *et al.* 1998). Stotz *et al.* (1996) comments on this fact with particular reference to threatened Neotropical birds.

Baseline data, including assessments of population sizes densities and distributions, are essential for monitoring the status of threatened species and also for assessing the effects of conservation actions on their populations (Stattersfield *et al.* 1998). It is therefore vital, that the collection of both baseline data and habitat data feature highly on the list of priorities for reserve managers as these will not only provide the greatest insight into the approaches needed for preserving threatened species, but also provide a means to monitor their success.

## Managing Savannah Landscapes for Grassland Birds



**Figure 1.6:** *The cock-tailed tyrant, Alectrurus tricolor in the savannah grasslands of the Barba Azul Reserve; a savannah bird in need of conservation. The reserves main forest Island is just visible in the background.*

Understanding habitat/species interactions may be even more integral for the conservation of birds within protected areas of “non-equilibrium” habitats (See Figure 1.6). Savannah-mosaics, as a result of their dynamic nature, are prone to relatively rapid successional shifts in structure over small time scales depending on disturbance levels. It is thought likely that such shifts have significant effects on both individuals and communities within savannah-mosaics (Price *et al.* 2010) and empirical evidence suggests grassland birds may be most at risk (Skowno & Bond 2003).

Skowno & Bond 2003 assessed the avian communities of four distinct vegetation zones within the Savanna-mosaic of Hluhluwe-Umfolozi Park in South Africa. Bird assemblages were found to vary significantly between the open grasslands and each of three wooded habitats under survey, showing more than 70% dissimilarity in terms of avian species composition. In this survey, all of the wooded areas assessed represented successional stages in the mosaics ecology which would normally be under some level of natural control from wildfire and grazing. The authors were thus able to conclude that any change in the structure of this ecosystem, for example woody encroachment resulting

from a “hands off approach” to management, may lead to significant alteration in avian communities within the reserve. Grassland birds would likely be the most affected in this scenario as they would be expected to lose the greatest amount of habitat. In light of this survey, an important management concern for the conservation of grassland birds may be controlling or artificially implementing disturbance, for example through burning, in order to control succession.

However, it has also been suggested that the presence of various successional stages within a savannah-mosaic could be important for maintaining healthy, intact communities of grassland birds (Fuhlendorf *et al.* 2006). Fuhlendorf *et al.* 2006 assessed the importance of structural complexity on communities of grassland birds in North America. Fuhlendorf wanted to test the concept that heterogeneity should be the basis of conservation and ecosystem management for grasslands birds. The timing and pattern of burning was altered within tall grass prairie to create a heterogeneous mosaic of vegetation at variable successional stages and compared with an annual, spatially-uniform burn. The effect of this increased spatial diversity was evaluated on the grassland bird community.

The diversity of grassland birds was four times greater in areas where patch burning was applied. Species such as Henslow’s sparrow, *Ammodramus henslowii*, a near threatened bird whose numbers are currently in decline (IUCN 2010), only appeared in tall grass areas not burned for two years while killdeer, *Charadrius vociferus* and some species of sandpiper were more abundant in recently burnt areas. Many of the species which occurred in habitats where patch burning was applied were either less abundant or absent in uniformly burnt systems thus implying the patch treatment increased grassland species diversity probably by permitting areas of disturbed and undisturbed habitat to exist side by side (Fuhlendorf *et al.* 2006). Fuhlendorf *et al.* (2006) concluded that maintaining several successional stages within savannah-mosaics, through processes such as patch burning, may be greatly significant for conserving grassland birds.

This survey shows the need for reserve managers to consider the spatial distributions of managed burning. Additionally, if the aim is to specifically conserve certain grassland species, some knowledge of their habitat preference within the grassland would also be useful to ensure that burning is intelligently controlled so that their entire available habitat is not burned at once.

The management of protected Savannah ecosystems is integral to the successful conservation of grassland birds. Once priority grassland species have been selected we must endeavor to ensure that the correct type of data is collected to assist us in forming opinions on how best to conserve them. As previously mentioned, there is an obvious need to collect baseline and habitat data for all threatened birds and threatened savannah species are no exception. However, there is also a need to understand what type of habitat data will be useful in aiding conservation action and this requires some level of knowledge about the system which the species inhabit. The studies described above highlight the importance of assessing the fine-scale distributions of target conservation species with respect to their grassland habitat so that we can understand how they utilize

it in a spatial sense and determine any basis for preference. Integrated, baseline and distributional habitat data will assist reserve managers in making decisions on the best management strategies to implement within grasslands for the conservation of their key threatened avian species.



**Figure 1.7:** *Adult male cock-tailed tyrant, Cock-tailed tyrant, perched atop the tall grasses of the Campo limpo.*



**Figure 1.8:** *Adult male black-masked finch, Black-masked finch, caught in savannah mist nets.*

## 2.2. Study Aims and Objectives

The primary aim of this study was to survey key conservation species of grassland passerine present in the Barba Azul Reserve in Northern Bolivia in order to: assess the reserves importance for the conservation of these species; create baseline data for future monitoring of their populations within the reserve and highlight the habitat needs of these species in order to devise informed recommendations for their future conservation management. In order to achieve this, the objectives were as follows:

1. Map the extent of the grassland habitat and establish the extent and boundaries of different grassland habitat zones based on differences in vegetation composition. These data will be used to improve precision of subsequent abundance & density estimates while also allowing assessment of avian distribution within the reserves grasslands.

2. Establish baseline estimates of population abundance for three target species of savannah passerine known to be present within the reserves grasslands. These include two species considered globally threatened; the cock-tailed tyrant and black-masked finch (IUCN 2010), and one species considered an indicator species for good quality savannah habitat, the wedge-tailed grass finch, currently listed as least concern (IUCN *et al* 2010).
3. Assess target species distributions within the reserve's grassland, focusing firstly on temporal changes in distribution over time then on spatial changes in distribution over the range of grassland zones.
4. Assess the distribution of target species at a finer scale with respect to the botanical structure and composition of the savannahs grassland habitats, allowing evaluation of specific microhabitat requirements for each species.
5. Finally, to use all data to make recommendations for future work for the conservation of these species within the RBA.

## 2.3. Methods

### Savannah Habitat Mapping and Area Estimation

With the help of trained Bolivian Botanist, Aquilino Molina Olivera a basic map of the reserves major habitats was first constructed. GPS points and measurements of grassland sub-habitat boundaries were then taken and added to the map in order to allow rough estimation of habitat areas to be calculated. GPS points were collected using a GARMIN eTrex H GPS receiver and distance measurements between specific points were taken using the same device. Collecting these points and distances involved: walking along the boundaries of habitats especially: the limits of the CSS habitat; taking measurements of the approximate extent of CS habitat along the western and eastern boundaries of the reserve; measuring the length of the Cerrado Access trail and taking GPS points at the borders of wetland habitats and other reserve boundaries. The area of each Grassland zone was then roughly calculated, the GPS route planner function was used to obtain distances between GPS points along habitat boundaries. The areas of all grassland habitats north of the cerrado access trail line were estimated. It should be noted that some CSS exists south of this trail. However, it was not feasible to estimate the extent of this due to inaccessibility and time constraints. This area was therefore omitted from the study, but its estimation could be valuable for future work.

### Abundance Estimation and Distribution Assessment

***Transect locations and positioning:*** Distance sampling along line transects was selected as the survey method of choice as this is considered the quickest, most efficient and most

accurate technique for estimating species density in large open habitats where bird detectability is generally high (Bibby *et al.* 2000; Sutherland *et al.* 2005). Additionally line transects are useful for generating larger sample sizes compared with more stationary methods, such as point counts, as they allow detection of more birds per unit time while the observer moves through the habitat (Bibby *et al.* 2000). This was important for this study as it was time-restricted and the primary aim was to survey threatened species that were more likely to exist at low density.

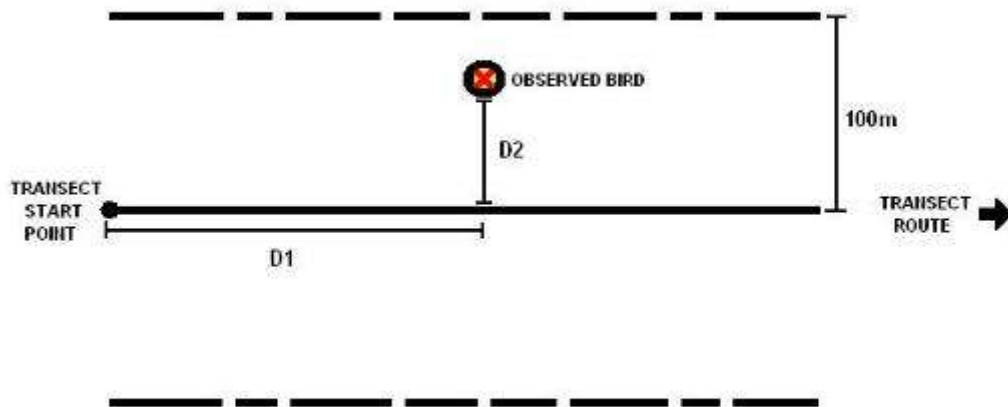
Transects were marked out over two days from July 28<sup>th</sup> 2010 – July 29<sup>th</sup> 2010. A systematic approach was used, as recommended by Bibby *et al.* (2000), with a fixed distance of 200m between adjacent parallel transects and a set transect length of 1.3km used as standard. Twenty-two transects were laid out in total. These were arranged in three sets: the first consisted of sixteen transects (T00–T15) crossing the savannah on a bearing of N20°W from start points positioned 150m from a broad Cerrado access trail running east from base camp on the north side of the main forest island (See Figure 1.3); the second consisted of 5 transects (SF1-SF5) commencing into the savannah at a bearing of S60°E (i.e. perpendicular to those in the first set) from a small, open trail running from base camp toward the northern limit of the reserve (See Figure 1.3); the third consisted of one isolated transect, laid out at the farthest end of the reserve (FF1). Start points were marked with numbered wooden stakes and red tape. GPS points were also taken for each in order to make it easier for field assistants to locate them throughout the survey.

**Conducting line transects:** Transects were conducted six days a week from July 31<sup>st</sup> 2010 – September 3<sup>rd</sup> 2010. The order of survey was drawn at random and this process repeated after all transects had been surveyed once so that each transect was walked twice over the entire survey period. Transects were always conducted by a team of two people and observers were rotated systematically between teams in order to reduce any observer-related bias. The aim was to have two teams each conducting one transect daily in order that two transects could be completed each working day. Unfortunately, this was not always feasible as man power was limited and field assistants often had to be forfeited for other expedition fieldwork. This sometimes resulted in having only one transect conducted some days with three conducted other days to compensate. However, changes to the schedule were minimized as much as possible.

Since the birds were most active between the hours of dawn and mid-morning (Personal Observation), transects commenced at around 06:25hrs (sunrise) and continued until around 09:30hrs. In each team of two, one person was responsible for searching the area forward and to the left of the line transect while the other was responsible for searching the area forward and to the right. Speed of walking was slow, around 0.5km/hour, and regular stops were made for several minutes every 50m to scan the horizon for avian activity. A hand compass was used to maintain accurate direction at the specified bearing and binoculars were used to search for the birds.

On visual detection of a target species, time of observation was recorded along with sex and number of individuals present. A GPS was used to measure the distance of the individual “along” the transect - this was defined as the distance from the “start”

waypoint of the transect to the point along the length of the transect which fell level with the observed bird. Similarly, a GPS was used to measure the distance of the bird “from” the transect - this was defined as the perpendicular distance from the transect to the bird and was measured by walking out to the point where the bird was observed and taking the distance from the corresponding “along” waypoint (See figure 3.1). Distances were measured to the nearest meter. Birds spotted directly on transect were recorded as having a “from” distance of 0m. Flying birds were recorded as “flying” and were excluded from the survey. Birds detected at perpendicular “from” distances greater than 100m were considered off transect and were excluded from the survey. Birds in groups of more than one were treated as a single data point but the number of individuals present for each sighting was recorded. In addition GPS locations were recorded for all birds. Each bird was also given a unique numerical code assigned as the numerical order of the observation.



**Figure 3.1:** Diagram outlining method used to collect bird position data. *D1* represents the distance “along” the transect; *D2* represents the distance “from” the transect. Adapted from image in Bibby et al.( 2000).

Identification and sexing of species was assisted, where necessary, with field guides including color plates extracted from Ridgley and Tudor (1994) and Van Perlo (2009)

**Assignment of Habitat Zones to Observation Data:** On return from the field, each bird observation was also assigned to a specific grassland sub-habitat based on its distance along each transect, with respect to the extent of the habitat as measured in section 3.3.

**Data Analysis for Population size:** The abundance estimation software, Distance 6.0 was used to assess the abundance and population size of each target species. (Thomas 2010). Detection curves were fitted to observation data for each species. For the Wedge-tailed

grass finch, a half normal key was fitted to the data (AIC value = 757.6) with 8 function evaluations used to achieve convergence. For the Black-masked finch a half normal key was also fitted to the data (AIC value = 678.99) with cosine adjustments of the orders 2, and 12 function evaluations used to achieve convergence. Finally, for Cock-tailed tyrant a half normal key was again fitted to the data (AIC value = 202.2) with cosine adjustments of the orders 2 and 12 function evaluations used to achieve convergence.

In this survey, two abundance analyses were performed. In the first analysis, the data were stratified by survey period, giving separate and pooled, population abundance and density estimate for survey period 1 (SP1) and Survey period 2 (SP2). SP1 includes all survey data collected during the first walk of each of the 22 transects from the 31<sup>st</sup> July 2010 to the 16<sup>th</sup> August 2010, SP2 includes all survey data from the second walk of each transect from 17<sup>th</sup> August 2010 to the 3<sup>rd</sup> September 2010 and the pooled survey period (PSP) uses all the data from SP1 and SP2, considering each sample period as replicates. In the second analysis, the data points were stratified by grassland habitat zone, giving separate abundance estimates for the area of each grassland habitat, CSS, CC/CS, CL/SF & WET population abundance for each habitat type were calculated based on the calculated area for each habitat type.. These data were not pooled, but rather total abundance was calculated additively to provide an abundance estimate for the global grassland area.

Abundances were therefore estimated by two separate methods, the results of each have been provided and their relative merits will be discussed later in the text.

***Statistical Analysis for Distribution:*** The line transect data analyzed with Distance 6.0 were also assessed for evidence of distributional differences between the birds. Abundances between SP1 and SP2 were compared for evidence of temporal differences in distribution. Density estimates were also compared between habitat types for evidence of a spatial difference in distribution.

## **Microhabitat Preference Assessment**

***Habitat data collection:*** Habitat data were collected from July 31<sup>st</sup> 2010 – September 3<sup>rd</sup> 2010 in conjunction with the collection of distance sampling data from line transects. A range of habitat variables were recorded at the site of each target species observation, referred to hence-forth as bird sample plots (BSPs). Habitat measurements were gathered from BSPs whilst conducting transects. Random habitat measurements were also taken at a set of random sample plots (RSPs). These data were gathered on the return trip along transects at five pre-determined points at set distances from its start point.

At each RSP and BSP, vegetation was sampled within a 0.5 x 0.5 m quadrat. Three quadrats were thrown and analyzed at each plot. To reduce bias, the observer was blindfolded and spun three times before throwing the quadrat, with exception of the first quadrat taken in a BSP, which was always centered on the perch where the bird was observed. Several variables were recorded for each quadrat; these are shown in Table 3.1 with notes on their measurement. Some additional factors were also recorded for the area

surrounding the quadrat; these are also outlined in Table 3.1. All height measurements were taken using a 3 meter retractable tape measure and recorded in millimeters.

Variable	Measurement Notes
1.Grasses Seeding:	Presence or absence of seed heads on any grasses
2.Other flowering/seeding:	Presence or absence of seeds, flowers or fruits on any plant other than grasses.
3.Short grasses present:	Presence or absence of grasses measuring <1.3m in height.
4.Tall grasses present:	Presence or absence of grasses measuring >1.3m in height.
5.Shrubs:	Presence or absence of small non-woody plant species
6.Bushes:	Presence or absence of small or medium woody plant species.
7.Trees:	Presence or absence of tall woody plant species including palms and other trees.
8.Worm Mounds:	Presence or absence of worm mounds
9.Depth of worm mounds	Depth of worm mounds if present
10.Tallest Grass:	Precisely recorded with a tape measure
11.Average vegetation height:	Estimated visually against tape measure scale
12.Surrounding vegetation:	Presence or absence of bushes or trees in area surrounding quadrat (up to 100m)
13.Termites	Presence or absence of termite mounds in area surrounding quadrat (up to 20m)

**Table 3.1:** *Variables recorded at each bird sample plot and random sample plot. Variables 1-7 represent within-quadrat categorical vegetation variables. Variables 8-13 represent further ecological variables collected for each quadrat.*

**Data Analysis:** Bird Sample Plot (BSP) and Random Sample Plot (RSP) data were combined for analysis with the statistical software program TWINSpan (Two-way indicator species analysis). Only categorical, within-quadrat vegetation variables (1-7 in Table 3.1) were used for this analysis. TWINSpan sorted the samples into sub-groups, making a series of nested divisions based on the similarity of indicators (variables) within the data. The program produces eigenvalues (denoted as e) to support the strength of these divisions; a multivariate probability assessment of the strength of separation of groups within the classification hierarchy. An eigenvalue approaching zero indicates that the separation of groups is approaching random, an eigenvalue approaching the maximum possible value of 1.0 would indicate that the two groups have almost no commonality. The groups produced therefore represent sub-sets of the total data, organized by their similarity, with specific indicators that are characteristic of that group (See Appendix 2).

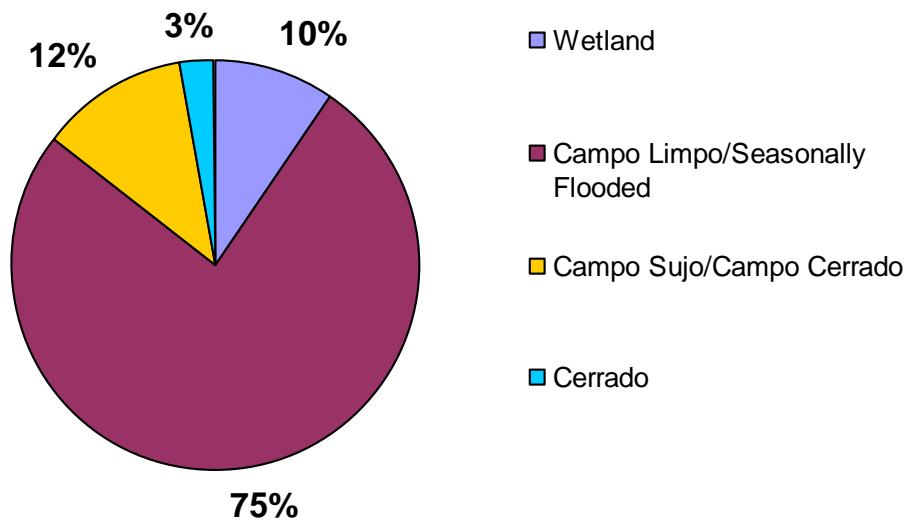
The data were evaluated for variation in species presence with respect to their proportion in each TWINSpan group and to the indicators specified by the program. Further, groups were compared for differences in ecological variables collected in the field (8-13 in Table 3.1). A one-way ANOVA was used to assess variation in mean values of continuous ecological variables (9 -11 in table 3.1) between the groups, while a Chi<sup>2</sup> was used to assess for differences in observed categorical variables (8, 12 and 13 in table 3.1)

## 2.4. Results

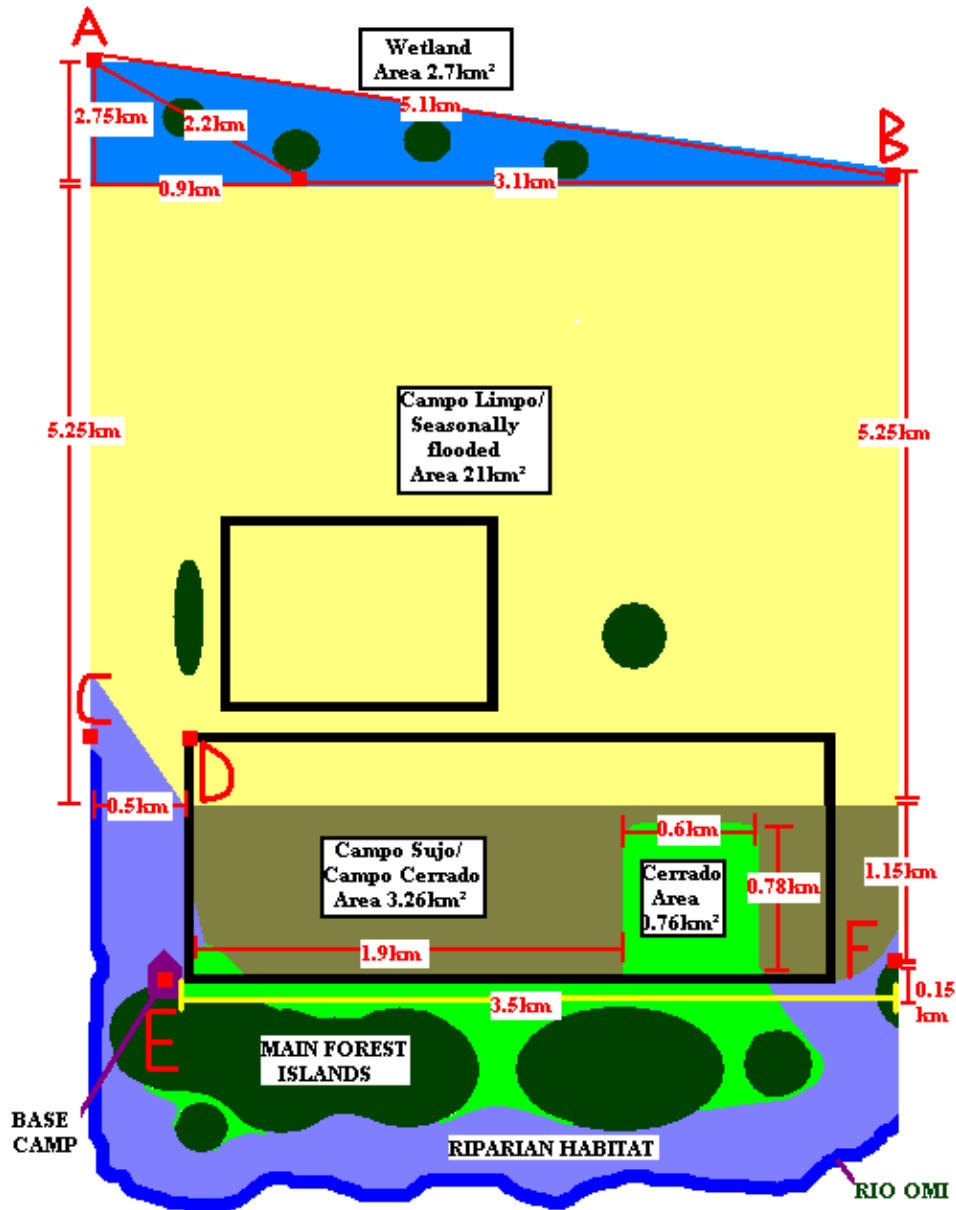
### Grassland habitat zones and Total Grassland Area Estimation

The habitat zone map compiled in the field is shown in Figure 4.2. Of all grassland habitats estimated, CL/SF was the most abundant, covering 75% (21km<sup>2</sup>) of the grassland area, CS/CC and WET covered similar proportions of the grassland, 12% (3.26km<sup>2</sup>) and 10% (2.7km<sup>2</sup>) respectively, while CSS was the least abundant grassland habitat covering only 3% (0.76km<sup>2</sup>) of grassland area (See Figure 4.1). The total grassland area within the reserve is thus estimated to be around 27.7km<sup>2</sup> (2772Ha).

**Estimated Proportion of Grassland Sub-habitat Types in the Reserva Barba Azul**



**Figure 4.1:** *Estimated proportion of grassland sub-habitat types within the total grassland area of the RBA.*



**Figure 4.2:** Habitat map of the Reserva Barba Azul. The basic layout of all habitats within the reserve is shown. Area estimates are indicated for each grassland sub-habitat. Each habitat is indicated by a different color. The red squares represent GPS points used to help calculate areas ( $A=S13^{\circ}41'26''/W66^{\circ}09'$ ;  $B=S13^{\circ}41'19''/W66^{\circ}06'44''$ ;  $C=S13^{\circ}41'59''/W66^{\circ}08'14''$ ;  $D=S13^{\circ}45.16''/W66^{\circ}07'43''$ ;  $E=S13^{\circ}45'60''/W66^{\circ}07'14''$ ;  $F=S13^{\circ}44'55''/W66^{\circ}05'54''$ ). The distance between GPS points was calculated using a GPS handset, via the route planner function. These distances were integrated with several distance measurements taken in the field and together used to calculate rough areas of each habitat. The cerrado access path is indicated in yellow and the black hollow boxes represent areas within which the transects were positioned.

## Abundance Estimates

A total of 191 observations were of the three target species over the total survey period, with a total sample effort of 57.2km (28.6km of line transects, each sampled twice over two survey periods). Total observations for each species, wedge-tailed grass finch, black-masked finch and cock-tailed tyrant were 89, 79 and 23 respectively.

**Temporal Variation in Species Abundance:** Based on pooled data from sample period 1 (SP1) and sample period 2 (SP2) for a total grassland area of 27.7km<sup>2</sup>: Estimated density was 0.272 individuals/hectare for Wedge-tailed grass finch (95 % CI 0.209 - 0.305); 0.270 individuals/hectare for Black-masked finch (95% CI 0.214 - 0.343) and 0.079 individuals/hectare for cock-tailed tyrant (95% CI 0.046 - 0.137). Producing population estimates of: 754 wedge-tailed grass finch (95 % CI 580 - 980); 750 black-masked finch (95% CI 592 - 950) and 220 cock-tailed tyrant (95% CI 127 - 381). Density and population estimates from each sampling period are shown in Table 4.1. Thus, populations of Wedge-tailed grass finch are predicted to be highest in the reserve, but only marginally, and populations of Cock-tailed tyrant to be lowest, at around 70% less than both Wedge-tailed grass finch and Black-masked finch.

However, given the extent of overlap between the 95% CI of wedge-tailed grass finch and black-masked finch and considering that their density estimates are almost exactly the same, there is little evidence to support that populations of these species are significantly different.

	Sample Period	N	DE/ha	Density 95% CI	SE	TAAE	Abundance 95% CI	SE
cock-tailed tyrant	SP1	13	0.090	0.039 – 0.204	0.038	249	109 - 567	105.8
	SP2	10	0.069	0.021 – 0.219	0.042	191	60 - 607	117.6
	PSP	23	0.079	0.046 - 0.137		220	127 - 381	
Wedge-tailed grass finch	SP1	39	0.254	0.164 – 0.392	0.056	703	454 - 1088	154.0
	SP2	50	0.291	0.208 - 0.407	0.049	805	575 - 1127	136.0
	PSP	89	0.272	0.209 – 0.305		754	580 - 980	
Black-masked finch	SP1	41	0.259	0.172 – 0.390	0.053	719	478 - 1081	147.8
	SP2	38	0.282	0.181 – 0.439	0.063	781	501 - 1218	175
	PSP	79	0.270	0.214 – 0.343		750	592 - 950	

**Table 4.1:** Abundance and density estimates for each target species, stratified by survey period. SP1 = survey period 1; SP2 = survey period 2; PSP = pooled survey periods; N = sample size; DE/ha = density estimate (individuals/hectare); TAAE = total area abundance estimate.

**Spatial Variation in Species Abundance:** Distances recorded in the field were used to divide each 1.3km transect into sections based on habitat type (See Figure 4.2) so that each bird observation could be assigned a habitat based on the distance that they were observed along each transect (See Table 4.2).

		Grassland Sub-habitat			
		CSS	CS/CC	CL/SF	WET
Transects	T0 - T9		0-1000m (10)	1000-1300m (10)	
	T10 - T12	0 -780m (3)	780 - 1000m (3)	1000-1300m (3)	
	T13 - T15		0-1000m (3)	1000-1300m (3)	
	T16 - T20			0 -1300m (5)	
	T21				0-1300m (1)

**Table 4.2:** Grassland sub-habitat divisions for Transects T0 – T21. The distances of the extent of each habitat along each transect are shown with the total number of transects for each category noted in parenthesis. CSS = Cerrado sensu stricto; CL/SF=Campo limpo/Seasonally flooded; CC/CS= Campo cerrado/Campo sujo; WET = Wetland grassland

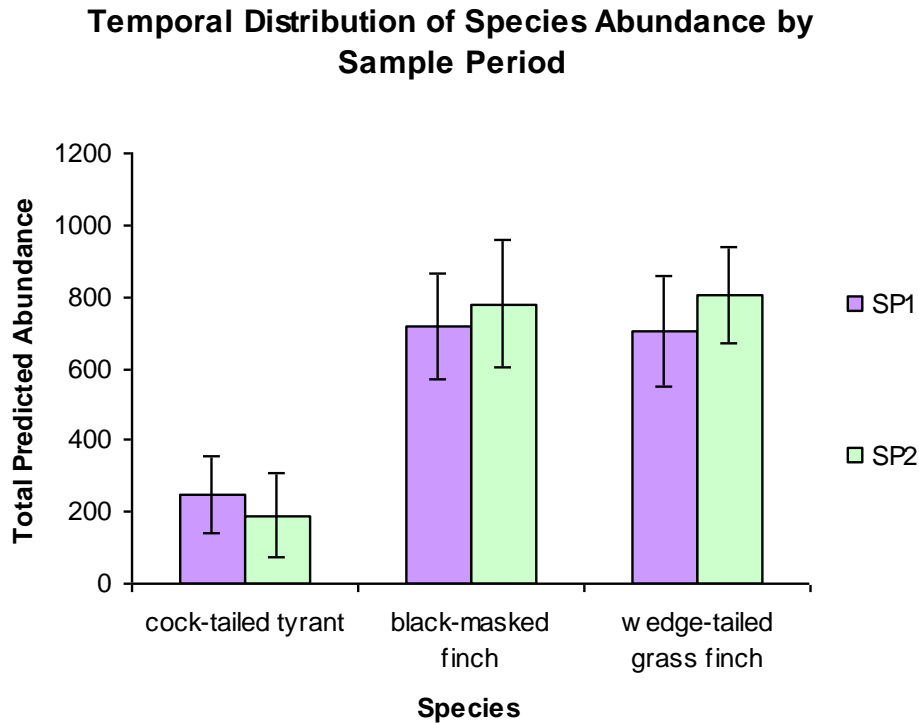
Based on 191 target species observations and a total sample effort of 57.2km - distributed over 41 transect sections of varying length, each separated by habitat type (See Table 4.3) and sampled twice: estimated abundance was 768 for black-masked finch; 750 for wedge-tailed grass finch and 427 for cock-tailed tyrant. Thus despite being the most frequently observed species over the whole survey period, the population of Wedge-tailed grass finch was not estimated to most abundant overall, with an estimated population size lower, but similar to that of Black-masked finch. Estimated populations of Cock-tailed tyrant were the lowest, at around 56% less than both Wedge-tailed grass finch and Black-masked finch.

	Habitat	N	DE/ha	Density 95% CI	SE	HAAE	Abundance 95% CI	SE
cock-tailed tyrant	CSS	0	0.000	N/A	N/A	0	N/A	N/A
	CL/SF	22	0.189	0.088 – 0.406	0.074	398	186 – 852	155.4
	CC/CS	0	0.000	N/A	N/A	0	N/A	N/A
	WET	1	0.053	0.034 – 0.082	0.011	29	19 – 44	6.1
black-masked finch	CSS	6	0.253	0.098 – 0.649	0.086	19	7 – 49	34.1
	CL/SF	29	0.300	0.167 – 0.539	0.088	630	351 – 1131	185.5
	CC/CS	43	0.276	0.188 – 0.406	0.053	90	61 – 132	14.3
	WET	1	0.053	0.043 – 0.066	0.006	29	23 – 36	3.2
Wedge-tailed grass finch	CSS	10	0.319	0.099 – 1.033	0.133	24	7 – 78	10.0
	CL/SF	37	0.292	0.215 – 0.396	0.045	613	452 – 831	94.4
	CC/CS	41	0.279	0.180 – 0.434	0.061	91	59 – 141	19.8
	WET	1	0.041	0.034 – 0.048	0.004	22	18 – 26	1.9

**Table 4.3:** Abundance and density estimates for each target species, stratified by grassland sub-habitat. CSS = Cerrado sensu stricto; CL/SF =Campo limpo/Seasonally flooded; CC/CS = Campo cerrado/Campo sujo; WET = Wetland grassland; N = sample size; DE/ha = density estimate (individuals/hectare); HAAE = Habitat area abundance estimate.

## Distribution Assessment

**Variation in Temporal Distribution of Species:** Overall target species observations between survey periods were similar, 93 in SP1 and 95 in SP2. Number of individuals observed between SP1 and SP2 were also similar for each species, though marginally higher in SP1 for both Cock-tailed tyrant (56% in SP1 and 44% in SP2) and Black-masked finch (52% in SP1 and 48% in SP2) and marginally lower in SP1 for Wedge-tailed grass finch (44% in SP1 and 56% in SP2).

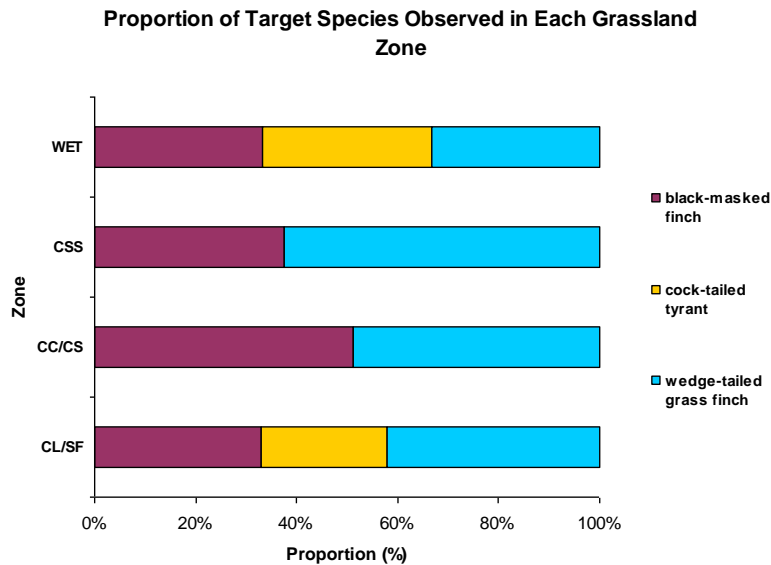


**Figure 4.3:** Abundance estimates stratified by sample period for each target species. SP1 = sample period 1; SP2 = sample period 2. Standard error has been indicated for each sample period estimate.

Abundance estimations showed a slightly different pattern (See Figure 4.3). Cock-tailed tyrant, were estimated to be more abundant in SP1, 249 individuals (95% CI 109-567) compared with SP2, 191 individuals (95% CI 60-607). Wedge-tailed grass finch, were estimated to be more abundant in SP2, 805 individuals (95% CI 575-1127) compared with SP1, 703 individuals (95% CI 454-1088). However, black-masked finch abundance was estimated to be higher in SP2, 781 individuals (95% CI 501-1218) compared with SP1, 719 (CI 475-1081).

Thus overall, all birds except Cock-tailed tyrants were estimated to be more abundant in the second portion of the survey. However, given the extent of overlap in standard error for all species between the two sample periods, there is little evidence to support that this difference is significant.

**Variation in Spatial Distribution of Species:** Wedge-tailed grass finch and Black-masked finch were observed in all of the grassland zones but Cock-tailed tyrants were only observed in CL/SF and WET habitat (See Figure 4.4).



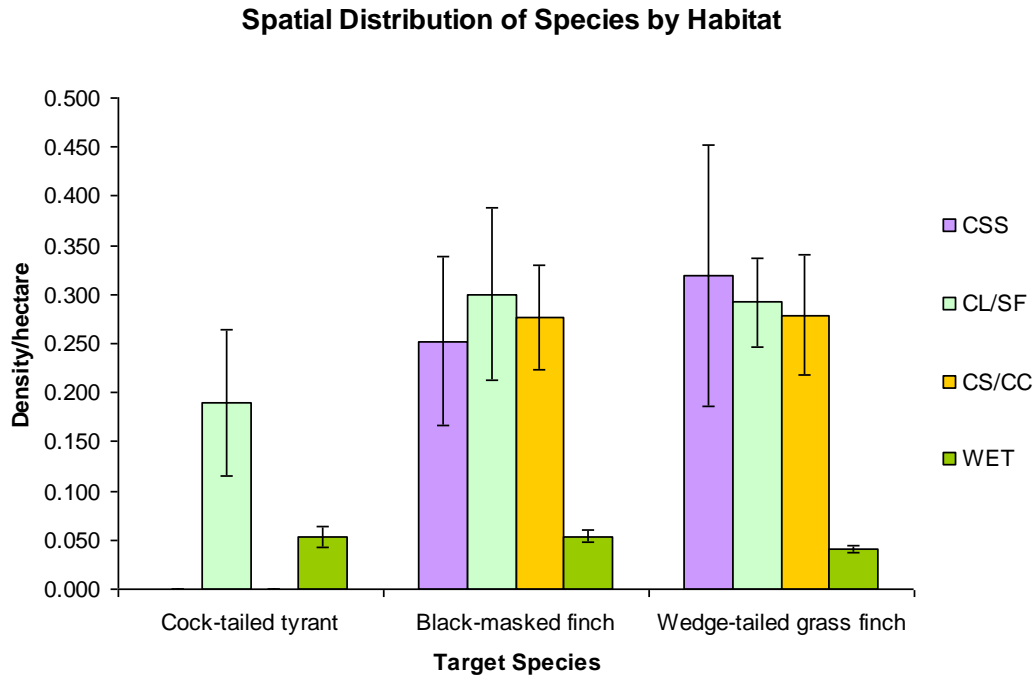
**Figure 4.4:** *Proportion of Target Species Observations for Each Grassland sub-habitat.*  
*CSS = Cerrado sensu stricto; CL/SF = Campo limpo/Seasonally flooded; CC/CS= Campo cerrado/Campo sujo; WET = Wetland grassland*

In WET habitat all species were observed infrequently but in equal proportions (only one observation of each species). In CL/SF habitat Wedge-tailed grass finch were the most frequently observed species (42% of observations) and Cock-tailed tyrant the least (25% of observations). Wedge-tailed grass finch were also the most frequently observed species in CSS (63% of all CSS observations) while observation frequency was similar in CS/CC for both Wedge-tailed grass finch and Black-masked finch.

Species density estimates for each sampled zone are shown in figure 4.5. These are based on a total sample effort of 57.2Km, split between each grassland habitat as: 4.7km of Cerrado sensu stricto (CSS); 22.6km of Campo limpo/Seasonally flooded grassland (CL/SF); 27.32km of Campo cerrado/Campo sujo (CS/CC) and 2.6km of Wetland grassland (WET).

Cock-tailed tyrants were estimated to have the greatest population density in CL/SF habitat, 0.19 individuals/hectare (95% CI 0.88E-1 - 0.406), over three times greater than their density in WET 0.53E-1 individuals/hectare (95% CI 0.34E-1 – 0.82E-1). Black-masked finch were also estimated to have the highest population density in CL/SF habitat, with 0.30 individuals/hectare (95% CI 0.167 – 0.539). Population density was estimated to be slightly lower in both CSS and CS/SF, 0.25 individuals/hectare (CI 0.98E-1 – 0.649) and 0.28 individuals/hectare (95% CI 0.188 – 0.406) respectively and lowest overall in WET, 0.53E-1 individuals/hectare (95% CI 0.43E-1 – 0.66E-1). Wedge-

tailed grass finch had the highest population density in CSS habitat, 0.32 individuals/hectare (97% CI 0.99E-1 – 1.03), slightly lower densities were estimated for CL/SF habitat, 29 individuals/hectare (95% CI 0.215 – 0.396) and CS/CC habitat 0.28 individuals/hectare (95% CI 0.18 – 0.43) and the lowest overall density was estimated for WET habitat, 0.41E-1 individuals/hectare (95% CI 0.34E-1 – 0.48E-1), eight times lower than the estimate for CS/CC habitat.

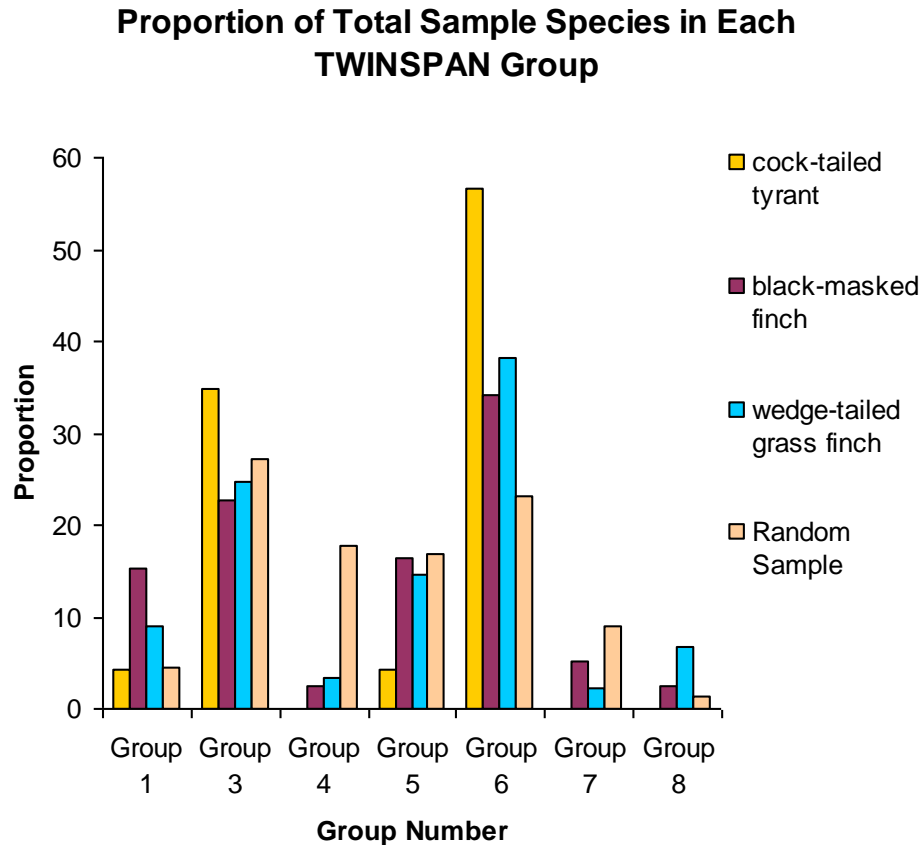


**Figure 4.5:** Density estimates for each species stratified by grassland sub-habitat. CSS = *Cerrado sensu stricto*; CL/SF = *Campo limpo/Seasonally flooded*; CC/CS= *Campo cerrado/Campo sujo*; WET = *Wetland grassland*

Thus CL/CS was found to hold the highest densities of cock-tailed tyrant and black-masked finch, CSS had the highest of wedge-tailed grass finch and the lowest densities of all birds were predicted in WET habitat. With the exception of WET habitat, both black-masked finch and wedge-tailed grass finch were more evenly distributed between the habitats with comparison to cock-tailed tyrants, found to be completely absent both in CL/CF and CC/CS. Further, given the extent of overlap in standard error between CL/SF, CC/CS and CSS for both black-masked finch and wedge-tailed grass finch, there is little evidence to support that there is any difference in density between these three habitats.

## Microhabitat Preferences

**TWINSPAN Groups:** The TWINSPAN analysis indicated the presence of eight sample-groups shown by different colors in Appendix 1. These were derived from a total of 411 samples (191 bird sample plots (BSPs), 220 random sample plots (RSPs)) and based on the presence or absence of 7 categorical, within-quadrat vegetation variables (See Table 3.1, Variables 1-7).



**Figure 4.6:** *TWINSPAN groups showing the proportion of total species and random samples in each group.*

**Group indicators and species proportions:** The proportion of total species in each TWINSPAN group are shown in Figure 4.6. Groups 1-4 were characterized by the absence of shrubs and 5-8 by their presence ( $e = 0.173$ ). Group 2 contained only two samples and as thus, will be disregarded as it is too small to analyze statistically.

Group 1 ( $N = 31$ ) is characterized by the indicators, bushes and seeding/fruiting/flowering non-grass species ( $e = 0.162$ ). This group contained far higher proportions of black-masked finch and wedge-tailed grass finch than random samples indicating that these species may select areas which have these qualities preferentially. However, proportions of cock-tailed tyrant were similar to random samples indicating

that they may not. Group 5 (N = 64) is, conversely, characterized by an absence of seeding/fruiting/flowering of non-grass species ( $e = 0.063$ ) and an absence of bushes ( $e = 0.064$ ). In this group, the proportion of black-masked finch and wedge-tailed grass finch are similar to the random samples.

Group 3 (N = 108) was characterized by a greater presence of tall grass ( $e = 0.101$ ). This group contained a high proportion of cock-tailed tyrants, with regards to the total observed in the survey. Also, the proportion of cock-tailed tyrants in the group was considerably higher than both the random samples and each of the other bird species. This indicates that cock-tailed tyrants may preferentially select habitat that has this quality. In this group, black-masked finch and wedge-tailed grass finch showed proportions slightly lower but similar to random samples, indicating that tall grass (>1300mm) may not be important for these species.

Similarly, Group 6 (N = 125), amongst other characteristics, was also characterized by the indicator tall grass ( $e = 0.036$ ). This group had the highest proportion of observed cock-tailed tyrants in any group. In addition, the proportion of cock-tailed tyrants within this group was more than two times higher than the group proportion of random samples and considerably higher than proportions of both black-masked finch and wedge-tailed grass finch. However, in this group black-masked finch and wedge-tailed grass finch were proportionally higher than the random sample, on this occasion indicating a preference for tall grass.

However, while group 3 was characterized by the absence of both bushes and seeding non grass species ( $e = 0.162$ ) group 6, in which black masked finch and wedge tailed grass finch proportion was higher than the random sample, was also characterized by the absence of bushes but conversely by the presence of seeding non-grass species ( $e = 0.063$ )

Group 4 (N = 44) and Group 7 (N = 26) are both characterized by the absence of tall grass ( $e = 0.101$  and  $e = 0.036$  respectively). In both of these groups, cock-tailed tyrants were completely absent. Black-masked finch and wedge-tailed grass finch had much lower proportions than random samples. Furthermore, group 7 was characterized by the presence of seeding/fruiting/flowering non-grass species ( $e = 0.063$ ) with group 4 characterised by their absence. Both groups were also characterized by the absence of bushes.

Finally, Group 8 (N=11) is characterized by the presence of bushes ( $e = 0.064$ ). In this group, the proportion of wedge-tailed grass finch was considerably higher than random and the proportion of black masked finch was also higher. Cock-tailed tyrants were completely absent from this group.

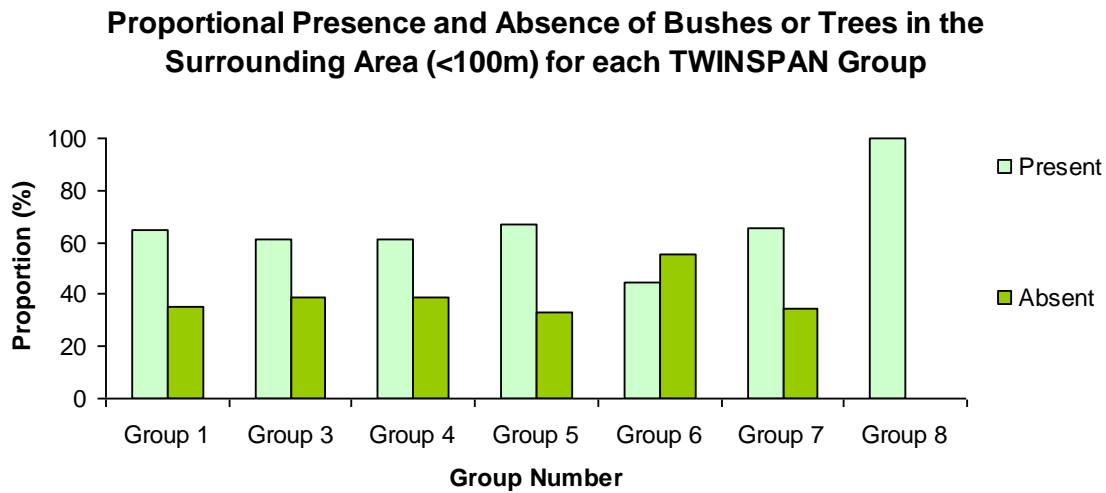
Variable	Group							ANOVA	
	G1	G3	G4	G5	G6	G7	G8	F	P
N	31	108	44	64	125	26	11		
Tallest Veg	1621 ±327	1703 ±337	1071 ±245	1488 ±392	1723 ±281	1049 ±428	2114 ±637	38.56	<0.001
Average Veg	716 ±194	741 ±174	527 ±207	690 ±170	742 ±187	532 ±274	708 ±169	11.82	<0.001
Worm Depth	76 ±72	133 ±81	113 ±80	99 ±73	145 ±70	100 ±76	76 ±64	6.5	<0.001

**Table 4.4:** Continuous environmental variables (mean± standard deviation) with ANOVA results (F and P values) comparing variables measured within each group. N = number of samples; Tallest Veg = height of tallest vegetation (mm); Average Veg = average vegetation height (mm); Worm Depth = depth of worm mounds (mm)

**Between group variation in ecological variables:** Differences in mean and standard deviation are shown for each continuous ecological variable and each group in Table 4.4. Results of the ANOVA revealed that all continuous ecological variables were significantly different between the TWINSPAN groups ( $p < 0.001$ ).

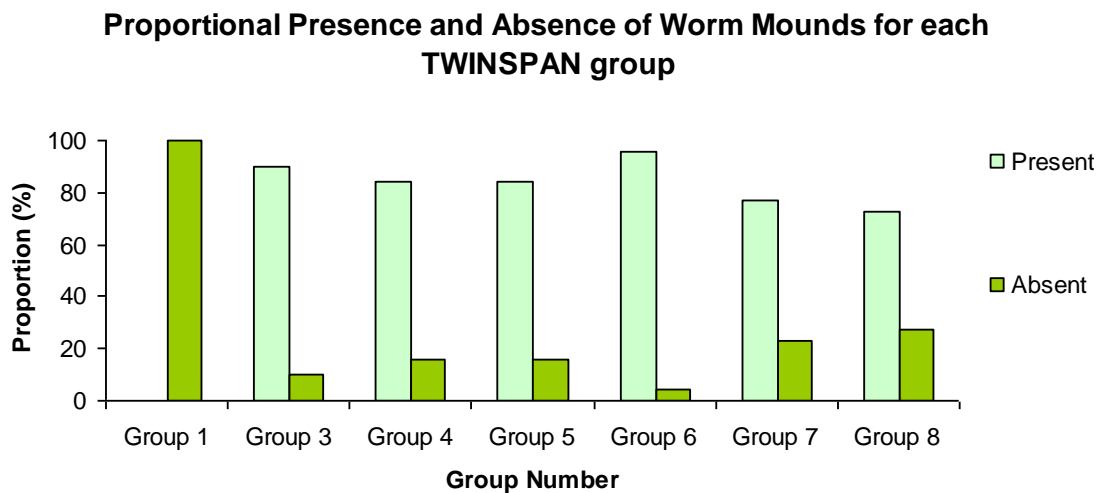
The highest mean value for tallest vegetation (TV) appeared in Group 8, a group characterized by the indicator, bushes present. This group also had the highest mean, average vegetation (AV) height. Mean values for TV and AV were also high in groups 3 and 6, groups both characterized by the indicator, tall grass and by the absence of bushes. These groups also had the greatest worm depth. Similarly, mean TV and AV was high in group 1, a group characterized by the indicator bushes. Means for TV and AV were lowest in groups 4 and 7, those groups characterized by the absence of tall grass and bushes.

Groups 6 and 3 had the greatest mean worm depth (WD). WD was similar in groups 4, 5 and 7 and lowest overall in Groups 8 and 1.



**Table 4.7:** *Proportional presence and absence of bushes and trees in the surrounding area (<100m) for each TWINSPAN group.*

Table 4.7 shows the proportional presence and absence data for the ecological variable, surrounding vegetation. Groups 1-5 show similar presence/absence patterns: around 60% of samples do have bushes or trees in the surrounding area (<100m) while around 40% do not. However, group 6 appears to have a higher proportion of samples with no bushes or trees in the area (55%) and in group 7, 100% of samples have bushes or trees in the area.



**Table 4.8:** *Proportional presence and absence of worm mounds for each TWINSPAN group*

Table 4.8 shows the proportional presence and absence data for the ecological variable, worm mounds. Groups 3-8 show similar presence/absence patterns: around 80% of samples do have worms while around 20% do not. However, group 6 seems to have slightly less samples where worm mounds are absent and in group 1, 100% of samples did not contain mounds.

The results of a  $\chi^2$  revealed that proportions of the categorical ecological variables “surrounding vegetation” and “worm mounds” were significantly different between the TWINSpan groups ( $p = 0.002$ ) and ( $p < 0.001$ ) respectively. Proportions of the variable “termites” was not found to significantly differ between the groups ( $p = 0.39$ ).

## 2.5. Discussion

The cock-tailed tyrant (CTT) and black-masked finch (BMF) are two largely unknown and little studied species of obligate grassland bird (Tubelis and Calvalcanti 2000; Fitzpatrick 1980; Lopez *et al.* 2009). Both are considered globally threatened, falling under the same IUCN risk classification of “vulnerable” (IUCN 2010). To date, no large scale studies have focused specifically on these species and scientific journals relating even vaguely to their abundance, distribution or ecology are exceptionally thin on the ground. Of the literature which does exist, a significant proportion is either unavailable in English or tends to offer only a paltry review of observational anecdotes regarding the characteristic habits and behaviors of each species (see Fitzpatrick 1980; Lopez *et al.* 2009; Sick 1993). Tubelis and Calvalcanti (2000) and (2001) provide the only two studies published and readily available which consider these species quantitatively and as thus will be referred to considerably.

In contrast, the wedge tailed grass finch is not globally threatened, falling under the IUCN extinction risk category of “Least Concern” (IUCN 2010). Although it is considered significantly more widespread and common than the other target species (Stotz *et al.* 1996), it is frequently observed alongside them in both non-flooded and seasonally-flooded grasslands (Parker and Willis 1997; Sick 1993; Tubelis and Calvalcanti 2000 and 2001). An understanding of the ecology of this species alongside the BMF and CTT may assist in explaining the absence of threatened target species from areas of seemingly suitable habitat across their respective ranges (personal comment).

### Habitat Zonation

Grassland makes up a significant proportion of the total reserve area, around 78%, making this habitat an extensive and important feature of the reserve. Within it, several habitat zones exist, the largest being an expanse of tall, seasonally flooded grassland occurring in the Bajios (flat low-lying regions) of the reserve. This zone, referred to as SF/CL grassland, is structurally comparable with Campo limpo (CL) (personal comment), being observed to generally lack the scattered trees and bushes described as

characteristic of the Brazilian Campo cerrados (CC) and Campo sujos (CS) (See Ratter *et al.* 2006; Sarmiento 1983; Ribeiro *et al.* 1983 as reported in Tubelis and Calvalcanti 2001). However it should be noted that some bushes are present within this zone, but that these are considerably infrequent and usually found associated with raised termite mounds. Like SF/CL, stands of wetland grassland (WET) also occur in the Bajios in the northern section of the reserve but these cover a considerably smaller area.

Additionally, two zones exist on a large semi-altura (mid-level region, between high ground forest islands and the low-lying bajios) which extends northward from the main forest island. Both of these zones are considerably smaller than the SF/CL. The first and largest, referred to as CC/CS, shares structural similarity with both the CC and CS habitats of the Brazilian Cerrado (personal comment), being observed to include the scattered trees and bushes typical of such regions (See Ratter *et al.* 2006; Sarmiento 1983; Ribeiro *et al.* 1983 as reported in Tubelis and Calvalcanti 2001). The second of these, and smallest of all zones under study, is the CSS which shares structural similarity with the Brazilian Cerrado *sensu stricto* (personal comment), being observed to include the denser wooded complement typical of that region (Ratter *et al.* 2006; Eiten 1972).

In each of the Bajio grassland zones, the absence of trees and bushes is likely controlled by flooding during the wet season, a factor that is known to act in excluding wooded vegetation in the low-lying flooded savannahs of the Llanos de Moxos (Langstroth (in press)). However, infrequent fire during the dry season might play some part in clearing infrequent bushes from raised termite mounds in this region (personal comment) and/or in maintaining its plant diversity (See Ratter *et al.* 2006).

In contrast, the proposed lack of flooding on the semi-altura during the wet season probably permits the growth of its more woody vegetation, since tree growth is associated with higher topography in the flooded savannahs of this region (Langstroth (in press); Mayle *et al.* 2007). However, as the distribution of woody vegetation is not uniform over the semi-altura, and tends to graduate from more wooded to less wooded as it extends out, there is probably some other factor controlling the relative balance of trees and grass in this area. Langstroth (in press) has suggested that the overriding factor dictating the relative composition of vegetation on semi-alturas in the Llanos de Moxos is the prevalent fire regime. This suggests that that the CCS and CC/CS zones could be susceptible to woody encroachment in the absence or suppression of fire within the reserve.

As Tubelis and Calvalcanti (2001) note, changes in vegetation structure are not abrupt and patchiness is common in savannah landscapes. Additionally, although the seasonally flooded savannahs of Bolivia are considered to share some similar elements of form similar to Cerrados, the overall habitat is also considered unique and distinct (Langstroth in press). Thus zones are presented, not as precisely measured, direct parallels of the Cerrado habitats they are likened to, but as broad divisions of the overall grassland into areas which are roughly structurally similar in vegetative form. Likening their structure to Cerrado habitats is based on the observed component vegetation types present in each and is intended to allow broad comparison between the habitat use of target bird species

within the RBA to the small number of studies and observational data available, most of which stem from work in the non-flooded Cerrados of Brazil (see Tubelis and Calvalcanti 2000; Tubelis and Calvalcanti 2001; Lopez *et al* 2009).

## Abundance Estimates

***Cock-tailed tyrant (CTT)***: This species had the lowest population of all the target birds in assessments of both temporal and spatial abundance. Little difference was found in the temporal analysis of species abundance between survey periods for the CTT. However, substantial differences were noted in its spatial abundance between grassland zones. This is consistent with the view that the species is a grassland specialist (Fitzpatrick 1980; Ridgley and Tudor 1994; Tubelis and Calvalcanti 2000) as findings suggest that the species use only parts of the RBA grasslands preferentially, rather than having a uniform abundance throughout. Tubelis and Calvalcanti (2001) also found evidence that CTT abundance was not homogenous along the Cerrado sensu lato (CSL) gradient with species confined to just two of four cerrado grassland habitats.

Consequently, and coupled with the fact that this bird is considered globally threatened (IUCN 2010), it is not entirely unexpected that the population of this species within the reserve is relatively low with comparison to the wedge-tailed grass finch (WTGF) which is not considered to be globally threatened (IUCN 2010) and appears in the studies of Tubelis and Calvalcanti (2001) to be more generalistic in its habitat selection over the CSL gradient, appearing in four out of four CSL grassland habitats.

As a consequence of the CTTs apparent preference for particular zones within the grassland, it is likely that spatial abundance estimates provide a more realistic representation of the CTT population size within the reserve. Thus, if the estimates achieved in this study are correct, the CTT population within the reserve is around 427 individuals.

Although global population size has not been directly estimated for this species, Birdlife (2010) currently lists the CTT as falling within the IUCN red list population criterion band of 10 000-19 999 individuals. Placement in this band is based on a density of one individual per km<sup>2</sup> (i.e. 0.01/hectare) in an estimated 2% area of occupancy (AOO) over its total estimated range of 626 000km<sup>2</sup> (i.e.12 520km<sup>2</sup>). If the estimates achieved in this study are correct, that would indicate that currently the RBA holds roughly 2.14% - 4.27% of the global estimated population of cock-tailed tyrants in an area less than 1% of their total estimated AOO (i.e. 23.7km<sup>2</sup> of 12 520km<sup>2</sup> when only CL/SF and WET are considered). This suggests that the RBA is a significantly important area for the protection of this species. Additionally, based on spatial estimations of density within the CL/SF and WET zones, the population within the reserve may exist at between 5-18 times greater density than Birdlife 2010 currently project.

***Black masked finch (BMF)***: The results suggest that the BMF population within the RBA is reasonably healthy. In both temporal and spatial analyses of abundance, this species was estimated to have a population size comparable with the more widespread

and common species under survey, the WTGF and also considerably higher than the estimated population size of its threatened counterpart, the CTT.

Although it seems counter intuitive that they should exist at a higher density than the CTT since they share the same IUCN red list category and population band, at 169 000km<sup>2</sup> (Birdlife 2010d), the estimated range size of the BMF is considerably more restricted, 73% smaller than that of the CTT (See Birdlife 2010c). Thus although it may be locally common in an area, it is still considerably threatened. Stotz *et al.* (1996) considers the BMF an uncommon species but describes its relative abundance to be patchy throughout its small range. Further, while some report it to be rare but locally common (Ridgley and Tudor 1994), Tubelis and Calvalcanti (2001) found it proportionally less abundant than both the CTT and WTGF in their surveys of sites in the Brazilian Cerrado. Considering this, our results suggest the species to be locally common within the RBA and suggest the reserves importance for these birds.

Again, for this species, little difference was found in the temporal analysis of abundance between survey periods. Similarly, little difference was apparent in spatial abundance throughout most of the habitat zones (CL/SF, CC/CS and CSS). The two analyses therefore estimated very similar population sizes for the reserve. However, like all of the birds under survey, the BMF was less abundant in WET habitat. It is therefore likely that spatial abundance estimates provide a more realistic representation of the BMF population size within the reserve. The results of this analysis suggest that the BMF population within the reserve is approximately 768 individuals.

Birdlife (2010) currently lists BMF in the same IUCN red list criteria population band as CTTs, between 10 000-19 999 individuals. Unfortunately Birdlife (2010) do not project an estimated AOO, for its range size but do suggest that if a species total range is greater than 10 000km<sup>2</sup> and if the species is not a habitat specialist, the projected AOO could be approximated as 10% of total range size. In this study, BMF were found to be present in all four habitat zones within the reserve, indicating it is likely not to be a grassland habitat specialist. Thus, very roughly, their estimated AOO may lie somewhere around 16 900km<sup>2</sup>. Thus if abundance estimates achieved in this study are correct, would mean that currently the RBA holds approximately 3.8% - 7.7% of the global estimated population of BMF in an area less than 1% of their total estimated AOO (i.e. 27.7km<sup>2</sup> of 16 900km<sup>2</sup> when all grassland zones are considered). This indicates the significance of the RBA as a stronghold for this species and an important site for its conservation.

***Wedge-tailed grass finch (WTGF):*** This species showed similar abundance to BMF in both the temporal and spatial analyses. Again, little difference was found in the temporal analysis of abundance between survey periods for this species. Additionally, and like the BMF, little difference was apparent in its spatial abundance throughout most of the habitat zones (CL/SF, CC/CS and CSS). Hence the two analyses once more estimated very similar population sizes for this species within the reserve. However, as the WTGF was less abundant in WET, spatial abundance estimates probably provide a more realistic representation of their population within the reserve. The estimates achieved in this analysis indicate that the WTGF population within the reserve is around 750 individuals.

The WTGF is not considered globally threatened, and is currently listed in an extinction risk category of “least concern” by the IUCN (IUCN 2010). However, it is considered an indicator species of healthy savannah ecosystems (Stotz *et al.* 1996) and has been shown to be intolerant of land transformation for pasture (Tubelis and Calvalcanti 2000) thus its presence within the reserve is important to note. Although the presence of one indicator allows us to say very little about a habitat, when found in conjunction with other rare and threatened species it can be more strongly supported that the ecosystem is healthy (Stotz *et al.* 1996). Thus the presence of the WTGF alongside the threatened CTT and BMF provides some evidence that the reserves grassland is in reasonable shape.

## Distributional Assessments

**Cock-tailed tyrant (CTT):** As previously mentioned, little difference was found in temporal distribution of CTT between the two survey periods. However it should be noted that fewer females were observed during the second survey period than in the first. Additionally females seemed to somewhat disappear towards the end of the survey and despite multiple searches the week following completion of the fieldwork (aimed at photographing them), still none were observed. However, the males seemed to remain frequent throughout this time.

The breeding habits of the CTT have not yet been reported for the Beni savannah region. The species is known to commence breeding at the start of the wet season (September-October) in other parts of its range (Birdlife 2010). Males were noted to have the full tail plumage typical of breeding birds (Ridgley and Tudor 1994) throughout the survey (See Figure 1.7), suggesting that breeding had been or was occurring around the time of our fieldwork. Additionally, males were frequently noted in the company of one or more females up until the 20<sup>th</sup> of August, though, their renowned displays (Sick 1993; Ridgley and Tudor 1994) were, sadly, not sighted. Given that the approach of the wet season was immanent on our departure from the RBA perhaps this observational evidence points to females nesting at this time, but further study would be needed to confirm if this is the case. Further knowledge of the timing of breeding in this species would be useful when scheduling proposed management plans within the reserve to ensure minimal interference with this process.

Conversely, the CTT did show considerable variation in spatial distribution, more so than either of the other target species. They were only observed in CL/SF grassland and in WET, yet completely absent in both CC/CS and CSS. Species density was highest overall in CL/SF (0.19/hectare) and almost four times lower in WET (0.053/hectare).

The apparent selectivity of this species for particular habitat zones within the overall grassland area agrees considerably with other studies and records taken in similar habitats. During abundance studies of open grassland birds of a preserved area of Cerrado sensu lato in Brazil, Tubelis and Calvalcanti (2001) recorded the CTT to be present in only two out of four grassland sub-habitats. Birds were observed in both Campo limpo

and Campo sujo but despite repeated survey in the more bushy and wooded Campo Cerrados and Cerrado sensu stricto of the study site, the species was not once observed.

Similarly, Lopez *et al.* (2009) presents several records of CTT sightings from ten years of study across the Cerrado region of Brazil. Observations of the birds in Campo limpo habitats are frequent and in the seasonally flooded savannahs of Fazenda Monte Carmelo, they are also noted inhabiting campo sujos and *Campo sujo com murundus* (described as grassland with small trees growing on raised earth related to termite mounds). At the same site, one observation also notes their presence in swampy, wet areas known locally as “veredas”. However, not a single observation of this species is noted to be included in the more wooded habitats that he describes for other birds including areas portrayed as similar to our CC/CS and CSS.

The evidence points to this bird being a grassland specialist which is selective in its use of grassland sub-habitats. Our study highlights the particular importance of the SF/CL zone within the RBA for the conservation of this species and also to a lesser extent the WET. However, even though the birds are not thought to be as densely distributed in the WET zone, this area may hold some other importance for the birds, for example as a drinking site or an area to catch insects at dawn and dusk when large swarms of mosquitoes gather (personal comment). It is therefore critical that these areas of the reserve are preserved for the conservation of this species.

***Black masked finch (BMF):*** The spatial distribution of the BMF was altogether different from the CTT. It appeared to be less selective in its habitat choice within the reserve being found in all four survey zones. Relative density was also similar in all zones (between 2.5-3 individuals/hectare) with the exception of the WET grassland where its density was found to be considerably lower (0.05 individuals/hectare).

These results contrast considerably to those of Tubelis and Calvalcanti (2001) who found the BMF was only present in two of the four grassland sub-habitats in their study area. BMF were only recorded in the two less wooded habitats under survey and completely absent from the more wooded Campo Cerrado and Cerrado sensu stricto habitats. Likewise, Lopez (2009) in his ten year review of observations in Brazil only notes the species as being present in Campo limpo, Campo sujo and Campo sujo com murundus in the seasonally flooded savannah systems of Brazil, never mentioning their presence in the more wooded habitats described for other birds. Furthermore, BMF were not noted in a prior survey of the avifauna of the Cerrado sensu stricto in the region south of the reserves Cerrado access trail (Reekie 2010).

These studies imply that the BMF is in fact a little more selective in its habitat choice than our results suggest, as they indicate avoidance of grassland areas where woody plant density is very high, even within the reserve itself. However, unlike the Cerrado sensu stricto habitat that Reekie (2010) sampled south of the reserves Cerrado Access trail, the zone that we define as CSS is exposed to the grassland on all sides. Thus perhaps the birds utilize it more as an edge habitat and this may have inflated or inflated the estimates we see for BMF population size within the CSS zone as a whole.

Additionally, the study of Tubelis and Calvalcanti (2001) showed that BMF existed at a considerably lower density than the CTT, suggesting that the species was not locally common at that site. Thus perhaps the birds do preferentially select less wooded areas but can make use of a broader range of grassland habitats in regions where they are more locally common. This may be why we see them entering into the CSS zone of the RBA.

Our results suggest that the BMF is not a grassland habitat specialist, at least within the grasslands of the RBA, and can use multiple grassland zones. The reserves' SF/CL, CC/CS and CCS zones appear to have similar importance for the species. However empirical evidence from other studies suggests that the CSS may be less important for the species. Further, comparative studies conducted within the reserve imply the CSS is probably used more as an edge habitat. Additionally WET appears to be slightly less important as the birds exist here at lower density than in other zones. However as mentioned with respect to the CTT, this zone may hold some other importance for the birds, for example as a drinking site.

With respect to our results and evidence from elsewhere, the grasslands of the SF/CL and CC/CS zones are likely most important for this species and their protection is probably key for the conservation of the BMF population within the reserve.

***Wedge-tailed grass finch (WTGF):*** The distribution of the WTGF largely shadows the BMF. It occurs in all zones at similar densities, but appears at much lower density in WET. These results concur with those of Tubelis and Calvalcanti (2001) who found the species to be present in all of their study areas including Campo limpo, Campo sujo, Campo Cerrado and Cerrado Sensus stricto at reasonably similar levels of abundance, although marginally lower in the latter. Observations show that the WTGF was the most frequently encountered bird in the CSS (See Figure 4.4). Additionally, the species was often spotted off transect along the Cerrado access trail perched in trees (personal comment) suggesting that it may make more use of the CSS than the other survey birds. However, further assessments within the CSS would be needed to confirm this, particularly in the area south of the cerrado access trail. However if it were the case, the WTGF may stand to benefit at the expense of the other survey birds if this area increases (i.e. as a result of woody encroachment due to suppressed burning).

## **Microhabitat Preferences**

***Cock-tailed tyrant (CTT):*** This species was found to seemingly favor areas of tall grass (>1300mm), being completely missing from groups characterized by its absence and most abundant in groups characterized by its presence. Hence it is not surprising that they also they appear to occur most frequently in groups where the mean average and mean tallest vegetation height is relatively high (See G3 and G6, Figure 4.4). However, this preference would appear to be most noteworthy when tallest vegetation is considered, with the majority of CTT occurring in TWINSPAN groups which show mean measurements of tallest vegetation around 1700mm, a figure ranging between 80-650mm taller than that typical of other groups. The only group that does surpass this figure (G8)

does not contain CTT. However, unlike the groups in which the CTT is most common G8 is characterized by the presence of bushes; likely the reason why its mean tallest vegetation is so high. Similarly, G6, in which the majority of CTT samples fall, seems to have a considerably higher abundance of samples which lack bushes or trees in the surrounding area (See Figure 4.7). Therefore it seems that within the RBA, CTT prefer areas of tall grass (>1300mm) and tend to be found in areas where bushes are absent and the mean height of tallest grasses is higher than average.

These results are largely concurrent with observational data from several other sources which note the CTT as seeming to prefer areas of tall grass (Ridgley and Tudor 1994; Sick 1993; Parker and Willis 1997). They also agree with data collected by Tubelis and Calvalcanti (2001) which shows the species to be more frequently observed in less bushy areas along the Cerrado sensu lato gradient (i.e. Campo limpo and Campo sujo) and to the observations of Lopez *et al.* (2009) which never refer to the species as appearing in heavily wooded areas. In this study, we found CTT were particularly concentrated in the SF/CL zone, thus it is likely that this zone tends to have the tallest grasses and less bushes of all zones.

Studies have found links between the habitat choices and life history traits of bird species (see Seymour and Dean 2010) Therefore it is feasible that the apparent choice of tall grass areas by the CTT may have links to the life history traits of this species, for example feeding and breeding behavior. CTT are insectivorous birds who capture insect prey by a combination of aerial hawking and outward striking methods (Fitzpatrick 1980). In utilizing the aerial hawking method, a bird will typically perch in an exposed location, searching for flying insects which it snaps out of the sky during a brief upward sally, terminating back on the same perch (Fitzpatrick 1980). This conspicuous behavior was observed in several male CTT within the RBA simultaneously on the 5th of September during a morning observing the species.

Perhaps there is a selective advantage for a bird using such a feeding method to have a tall perch. For example, being more elevated may allow it to see proportionally more sky across the flat savannah landscape, an easier backdrop than grass from which to pick out flying insects. Tall grass areas may thus provide better feeding habitat for the CTT. If this was the case, then it would not necessarily be the height of the grass which is important in the grassland, but instead its relative height with respect to the rest of the grassland area. It would be interesting to compare the differences in grass height between areas where CTT are found within the RBA to other studies. Unfortunately this data is not yet available for other savannah regions.

Tall grass areas might also be important for breeding. Male CTT are renowned for their elaborate sexual displays and breeding plumage (Sick 1993; Tudor and Ridgley 1994). A taller perch may function as a better stage for this performance and act to attract more females. If this was the case we might expect to see congregations of CTT in areas where grasses are tallest. Further, given both feeding and breeding scenarios we might also expect some element of territorial behavior particularly in the breeding season as the tall grass could be considered a valuable resource for the birds and their partners. It is not yet

known if the CTT is a territorial bird but it is suspected of being polygamous (Sick 1993). If this is the case, perhaps females prefer males who defend taller patches of grassland.

What is also interesting is that the TWINSPAN groups containing the majority of the CTT appear to also be associated with worm mounds. G6, showed the highest proportion of samples with worm mounds present of all the groups (See Figure 4.8). Additionally both G3 and G6 had the greatest mean worm mound depth (See Table 4.4). Worm mounds are characteristically found across the flooded grasslands of the Beni. They are created by earthworms and held together by the roots of the bunch grasses which colonize them. The mounds are not flooded in the wet season and as thus allow the persistence of vegetation growth throughout the season. (Haase and Beck 1989) The reason the CTT appears to prefer such areas could be down to a number of things. If, as we stated earlier, the breeding season occurs just before the wet season, then perhaps, the raised mounds support vegetation for the birds to nest in while water levels rise. The worm mounds also create more heterogeneity in the grassland environment and perhaps increase insect availability as they create two distinct foraging zones, mounds and gullies (Haase and Beck 1989) CTT might supplement their more distinctive aerial hawking strategies with foraging in these areas.

Speculation as to the reasons why this bird appears where it does could be much written on. However, with respect to its conservation, what is more important is that this study has provided a much clearer picture of several factors regarding its ecology: firstly, we have an indication that it needs areas of tall grass; secondly that it seems to prefer less bushy areas and thirdly, that it appears to prefer areas where worm mounds are present. Thus within the SF/CL zone these are probably important features to note when considering the conservation of this species as its distribution throughout it probably correlates with these attributes.

***Black masked finch (BMF) and wedge-tailed grass finch (WTGF):*** These species showed very similar patterns in microhabitat preferences. In almost every TWINSPAN group, their frequencies were very alike and their pattern with respect to random samples comparable. This relationship between the two species is likely a result of their similar ecology. Both are members of the same family, the Emberizidae, of which most are granivores and chiefly feed on grass seeds, sometimes supplementing their diet with shoots, fruits and insects depending on the season (Sick 1993).

Both species seem to prefer areas where flowering/seeding/fruited non-grass species are present and also prefer tall grass areas, yet do not appear to be as dependant on specifically high regions of grass like the CTT. Nor do they seem to have a strong association with worm mounds.

They were found to occur at high frequencies in TWINSPAN groups G1 and G6, characterized by the presence of flowering, seeding or fruited non-grass species (See Figure 4.6). However, they occurred at low frequencies in groups G4 and G7 characterized by an absence of tall grass (>1300mm), even though G7 was also characterized by the presence of flowering, seeding or fruited non-grass species. They

also occurred at frequencies relative to random samples in one group characterized by tall grass, but by an absence of flowering, seeding or fruiting non-grass species (G3) but occurred at much higher frequency in another group (G6) characterized by tall grass which conversely was also characterized by the presence of flowering, seeding or fruiting non-grass species. Thus the results show a preference for areas where flowering/seeding/fruiting non-grass species are present and do indicate that the species avoid areas where tall grass is absent. Perhaps then the finches gather in such areas to make use of a potential food resource with which to supplement their diet.

Finches are known to congregate more densely in areas where specific food resources are available for limited periods of time. Sick (1993) notes this behavior in the buffy-fronted seedeater, *Sporophila frontalis* which gathers in great numbers alongside other finch species to feed on the bamboo, *Merostachys spp* during its short fruiting season in the mountains of Southeastern Brazil. While the results of this study do not demonstrate such a grand and pronounced gathering, they do suggest a neat but small scale comparison. It would be considerably interesting to see if there was any difference in the choice of non-grass resource type chosen by each species as this might provide insight into how two such similar birds can exist at such similar densities together. Perhaps this might show some level of niche partitioning between them and could even explain why the BMF is inexplicably absent in some areas within its range (Parker and Willis 1997).

Comparing between groups where the finches were more frequent than random, G1 and G6, and groups where they were more or less equally as frequent as the random sample, G3 and G5, mean vegetation and mean tallest vegetation heights across the board were similar. However in groups where they were less frequent than random, the grass heights were also found to be much lower. This indicates that the finches prefer taller grass areas but are not specifically tied to regions that are particularly tall. Additionally, comparing just between groups where the finches were more frequent than random, mean worm mound height seems considerably variable, suggesting that these species are not tied to specific areas where flooding is high (i.e. the SF/CL and WET zones) and again points to their more generalistic use of the grassland.

Both species are considered to be frequent users of tall grass savannahs (Sick 1993; Lopez *et al* 2009) but unlike the CTT, are not mentioned to be dependent on specifically tall areas. Thus the results of this study seem consistent with this view.

It is also interesting to note the higher abundance of WTGF in group 8, characterized by bushes, additionally around 80% of these samples were actually in trees, suggesting further that this bird may use the CSS more than the others. However, this was the smallest group of the study so it is best to exercise caution in what we derive from it.

With respect to the conservation of both the BMF and the WTGF, this study has provided a much clearer picture of several factors regarding their ecology: firstly, we have an indication that they may congregate in areas where plants, other than grasses are flowering/seeding/fruiting; secondly that they seem to prefer reasonably tall grass and that the BMF likely uses the CSS zone as an edge habitat. Thus these are probably

important features to note when considering the conservation of this species as its distribution throughout the overall habitat probably correlates with these attributes

## **Recommendations for the Future**

There is an enormous complexity involved in trying to manage such a dynamic habitat as a savannah for the conservation of wildlife. With respect to the species under study here, a considerable amount of research is obviously needed before any real recommendations on their conservation can be made as so little is known about them. However, the following is a summary of the points raised by this study which would be useful focuses of future work regarding these species within the reserve:

- Target species must be assessed with respect to their breeding habits so that future conservation management plans for the reserves grasslands do not interfere with this process.
- The importance of the CSS zone and the CSS vegetation in the area south of the Cerrado access trail needs to be reassessed with respect to its importance for both the BMF and WTGF as this study does not clearly show the areas importance for these species.
- If the CSS is found to be less important for the BMF as we suspect, then implementing some level of burning on the reserves semi-alturas would be advisable for conserving the grasslands here for this species. Patch burning would likely be the best strategy so that not all habitat is removed simultaneously. Additionally this would increase the amount of edge habitat, which we suspect may be well utilized by the birds.
- Likewise, the WET zone at the north of the reserve is in need of reassessment as to its importance for all target species as this area was not well represented in our study, with only two full transects in the region.
- Surveying the SF/CL zone in the region north of transects used in this survey is needed to confirm the importance of this area for all species, particularly the CTT. This would ensure that the birds are not simply congregating along the edge of the CC/CS and SF/CL zone boundaries.
- There is a clear need to retain areas of tall grass in the CSS, CC/CS and SF/CL zones of the reserve for all birds. However for conservation of CTT populations, particularly tall stands of grass in the SF/CL zone must be maintained, specifically where deep worm mounds are present.
- As the CTT also seems negatively associated with bushes, implementing burns or removing bushes associated with termite mounds in the SF/CL may be required to ensure they remain infrequent in this habitat. Also, although the lack of trees here

may not be primarily driven by fire, dry season burns could still be important for maintaining grass diversity in this region. Thus implementing patch burning here too might also prove to be important in maintaining the diversity of the grasslands themselves for bird species.

- Finally, now that baseline estimates of abundance and density have been achieved, continued monitoring is integral for assessing the effect of the reserves protection on these species and also the effects on conservation efforts stemming from any management strategies which are implemented by Armonia.

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### 3. Blue-Throated Macaw Study: Minimum Population size, Movement and Habitat Use of Pre-roosting Blue- Throated Macaws

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Alwyn McKenna

# Abstract

Determining and monitoring the abundance of the Critically Endangered blue-throated macaw, (*Ara glaucogularis*) within the Barba Azul Reserve is one of the primary aims of Bolivian Birdlife International partner, Asociación Armonía. Studies of the movements and behaviors of the blue-throated macaw are also considered important to further sparse existing knowledge of the species and assist in development and implementation of effective and focused management plans and long term monitoring strategies for their conservation. Estimating the overall abundance and distribution of this species has proven to be difficult due to the heavily fragmented nature of its populations and also to the remoteness and inaccessibility of its habitat. Consequently, relatively little literature is currently available on the subject. Birdlife International estimate the current global population of these birds at no more than 300 individuals. This project aims to investigate the abundance, movement, habitat use and behaviors of pre-roosting blue throated macaws within the Barba Azul Reserve.

We collected information on the distribution, abundance and behavior of the blue-throated macaw and compared it to the more common sympatric species, the blue and yellow macaw (*Ara ararauna*). To achieve this, multiple evening point counts and forest island roost site surveys were conducted. Analysis of the point count data showed that a minimum of 103 blue-throated macaws and 284 blue and yellow macaws were using the reserve prior to roosting. For the blue-throated macaw, this represents a third of the current, estimated global population of this species and hence, highlights the considerable importance of the reserve as a stronghold for its conservation.

Comparison of data with that recorded in 2009, suggests the overall abundance of the blue-throated macaw has increased since this period. Further, data collected during the forest island roost site surveys showed that although there were large evening congregations of both species, each flew further afield and probably roosted in areas out-with the reserves boundaries. Islands did however appear to act as important congregation points or ‘stop-off’ stations along the way. Additionally, the directional movements of the birds recorded in this study may assist future researchers in pinpointing the precise locations of overnight roost sites.

## 3.1. Introduction

The blue-throated macaw, *Ara glaucogularis* (Dabbene, 1921), is a critically endangered, endemic Bolivian species found on Appendix I and II of CITES. It has suffered significant population decline over the past three decades owing to extensive pressure from illegal trade as a result of both capture for the pet trade and hunting for their long tail feathers, utilized locally in ceremonious costumes and headdresses (BirdLife International, 2010). The birds are extremely valuable and fetch huge prices both domestically and internationally. The species has an extremely restricted habitat, being almost wholly confined to the seasonally flooded Llanos de Moxos savannah region of

the Beni Department in Northern Bolivia. In the wild, it is found utilizing forested savannah areas including gallery forest and raised forest islands (Yamashita, *et al.*, 1997). The current existing populations of this species are heavily fragmented and subject to ongoing conservation efforts by Association Armonia the Bolivian Birdlife International partner.

Asociación Armonía facilitate the preservation and regeneration of blue-throated macaw numbers through ongoing conservation programs involving population and distribution surveys, searches for further populations and outreach programmers to the local communities via educational promotion (Hesse, *et al.*, 2000) The known area occupied by *Blue-throated macaw* is estimated to be of 8600km<sup>2</sup> which is largely fragmented with low numbers found in different parts of this area (Hesse, *et al.*, 2000). Current population estimates vary, with BirdLife International (2010) estimating between 50 and 249 mature individuals with an estimated range of 12,900km<sup>2</sup>. However, Herrera and Hennessey (in press) predict the total population to be between 250 and 300 individuals. The largest single count of this flocking species was 70 individuals at a seasonally dry roosting site observed in 2007 (IUCN, 2010).

In 1988, following implementation of a law passed in 1983 against trapping of the blue-throated macaw and the subsequent passing of a law prohibiting the live exportation of the animals (Hesse, *et al.* 2000), the IUCN classified the blue-throated macaw as globally threatened (Birdlife International, 2010). Surveys conducted by Jordan *et al* (1993) supported this move and led to a reassessment of the species resulting in its reclassification as Endangered (Birdlife International, 2010). However, continual sharp decline in numbers lead to further reclassification by the IUCN in 2000 to place it in its current status of Critically Endangered (Birdlife International, 2010). To this day it is thought that illegal exporting still continues (Herrera & Hennessey, 2007). But encouragingly, Association Armonias parrot trade monitoring scheme has not detected that presence of any Blue-Throated Macaws being illegally exported in the past two years (IUCN, 2010).

## **Blue-throated and Blue and Yellow Macaw Status and Ecology**

Typically the Benian habitat of the blue-throated macaw consists of forested islands of variable size and gallery forest elements stretching along water courses, both present on Alturas (regions of elevated ground between 130m and 235m) and surrounded by seasonally flooded grasslands in bajios (in low elevation ground <130m) (WWF 2008). These forest fragments are occupied mainly by palm groves of the Motacú palm (*Attalea phalerata*), the flesh of which provides an important source of food for many vertebrate species within the Beni region and is considered the major food source of the blue-throated macaw (Duffield & Hesse, Parrots international). Jordan *et al.* (1993) have also reported observations of the species feeding on the nuts of another palm species, *Acromia aculeate* alongside observations of it opening immature or unripe Motacú nuts to drink the liquid from inside.

The blue and yellow macaw bears a close morphological resemblance to the blue-throated macaw and the species exist sympatrically in the same environment. However, unlike the blue-throated macaw, blue and yellows have a large geographical habitat range covering several countries in South America over an estimated area of 7,730,000km<sup>2</sup> (BirdLife International, 2010) and are listed under CITES Appendix II, classified by the IUCN (2010) as Least Concern. Even though blue and yellow macaw encounters the same threats as blue-throated macaw including, illegal trading, deforestation and habitat destruction, their populations have not declined to the same extent. Some have even suggested the possibility that blue-throated macaws are being out-competed by the larger blue and yellow macaw (Duffield & Hesse).

The social characteristics and behaviors of the blue-throated macaw remain largely unknown although they are considered a sociable species (IUCN 2010). They are frequently found together in pairs but have also been noted to socialize in small groups of 7 to 9 and may flock in considerably larger numbers (IUCN, 2010).

### **Current Threats to the Blue-Throated Macaw**

All of the known sites which contain sub-populations of the blue-throated macaw are found within privately owned cattle ranches. A common threat to these environments is the periodic burning and clearing of land to provide pasture for cattle (Hesse, *et al.* 2000). The felling of trees, in particular the Motacú, is also a considered problematic due to the species' use of this tree not only for feeding but as a nest site. Inter-specific competition from other species such as toucans, woodpeckers and other macaws, including the blue and yellow, may add additional pressure as these species compete for the same nesting environment.

Despite declines witnessed over the past 30 years, there are signs that the population may be slowly increasing, probably due to the extensive conservation efforts imposed by Asociación Armonía (BirdLife International, 2010). However, due to the severe fragmentation of the populations, concern regarding the genetic fitness of remaining populations is probably warranted

## **3.2. Previous Studies & Aim of this Study**

Due to the inaccessibility of the Beni region, sparse distribution, low population size and endemism of the blue-throated macaw, there has been little published work regarding the natural history, behaviour and distribution of the species.

In August 2009, a baseline study was conducted within the Barba Azul Nature Reserve by a group of students from the University of Glasgow and Bolivian scientists. This study collected provisional abundance data for the blue-throated macaw among other species and provided a baseline for this more detailed current study to be compared. From further work carried out in 2009 within the Barba Azul Nature Reserve, it has been estimated that the area holds approximately 70 individuals in the dry season and 20 individuals in the rainy season.

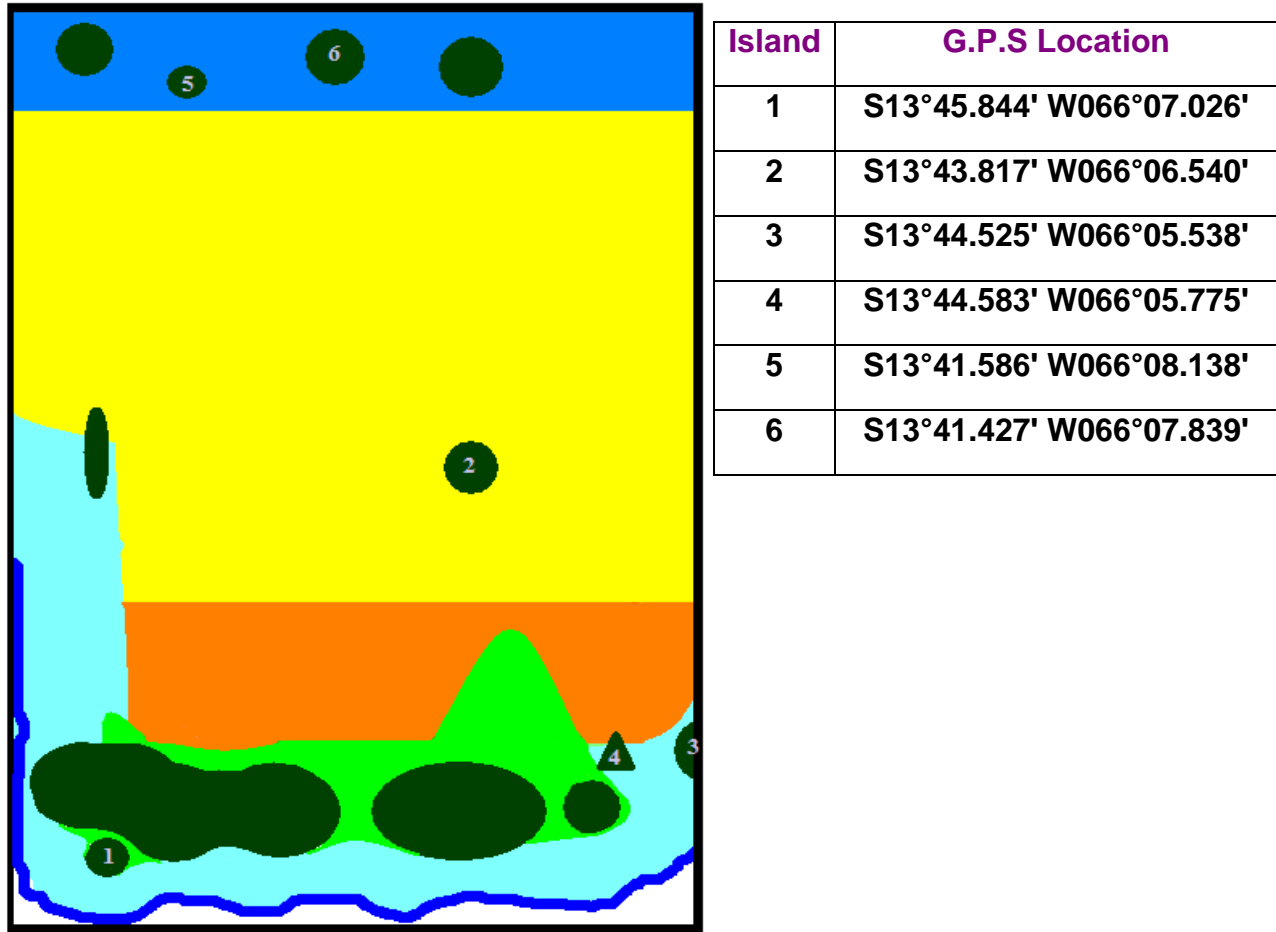
This study aimed to quantify the abundance and distribution of the endemic blue-throated macaw with comparison to the more prevalent blue and yellow macaw and investigate its behaviors. To do this work focused on collecting data during pre-roosting hours when parrots were easy observe and count as they gathered into flocks prior to roosting. In particular the aims of this study are to:

1. Carry out regular counts of the blue-throated macaw and establish pre-roosting movement patterns within the Barba Azul Nature Reserve in comparison to the blue and yellow.
2. Assess whether there are inter-specific behavioral differences or interactions between the two species of macaw at pre-roosting.
3. Estimate the population size of blue-throated macaw currently using the Reserva Barba Azul.

## 3.3 Methods

### Island Surveys

Collection of distribution and population data for the blue-throated macaw and blue and yellow macaw were conducted over a period of 5 weeks from the 2<sup>nd</sup> of August 2010 to the 4<sup>th</sup> of September 2010. In total 6 forest islands (Table 3.3.1) within the savannah were used for survey. Prior to the survey it wasn't known which islands the macaws were using regularly. A preliminary visit to each island was conducted in the week prior to the start of the systematic survey in order to familiarize ourselves with the terrain and traveling distances. Travel to and from the islands was on foot or by horseback depending on distance. Islands which blue-throated macaw were thought to use at least occasionally were located via information from locals from neighboring ranches and from associates of Asociación Armonía who had visited the Barba Azul Nature Reserve previously. Some islands were included in the survey even if it was unknown if *Blue-throated macaw* utilised them. Each forest island was visited once a week so that each island was visited 5 times over the survey period.



**Figure 3.3.1** Map showing the locations of each forest island (dark Green) in the Barba Azul Nature Reserve utilised in the island surveys and thier corresponding G.P.S location.

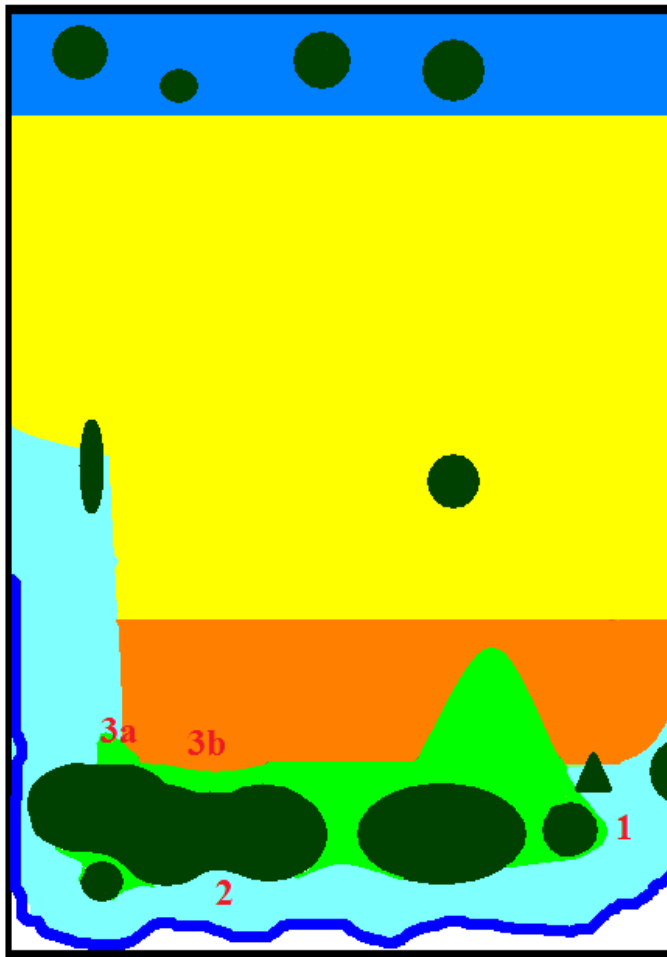
Information collected at each site included data for both blue-throated macaw and blue and yellow macaw. Data gathered were as follows: date, island number and G.P.S location of observation point, weather conditions, number of individuals/flocks observed, direction of macaw travel, time of arrival and departure of each individual/flock, distribution of the macaws in the trees (if landed), ratio of adults to juveniles (if detectable) and notes on any behavior exhibited. Pre-roosting time was determined to be one and a half hours prior to sun down based on the sightings of departure from the main island of both species of macaws in the initial week. Hence surveys started at each forest island at 17:00h and continued until 18:30h. Location data was recorded with hand held Garmin Etrex Global Positioning System (G.P.S) device.

<b>Island</b>	<b>Distance to Main Forest Island (m)</b>
<b>1</b>	<b>178</b>
<b>2</b>	<b>2189</b>
<b>3</b>	<b>810</b>
<b>4</b>	<b>413</b>
<b>5</b>	<b>7223</b>
<b>6</b>	<b>7185</b>

**Table 3.3.1** *Approximate distances of each island from the main forest island.*

## Point Count Surveys

Pre-roost population counts were also conducted for both the blue-throated macaw and blue and yellow macaw. Three stations were chosen at separate points around the main forest island where a maximum viewing distance was possible for observation. The first station was located at the most easterly point at the end of the main forest island with GPS location S13°45.491', W066°07.186'. The second station was located on the south side of the main forest island along the River Omi with GPS location S13°45.870', W066°06.990'. The third station was initially located approximately on the northside of the island 200m from the main camp at G.P.S location: S13°45.491', W066°07.186'. After 3 days of observation it was found that visibility of macaws leaving the forest was somewhat obstructed so this point was then moved to a location with a better all round view, 800m east along the man-made track running along northern side the main forest island at the G.P.S point: S13°45.297', W066°06.800'. Point count locations are shown on the map in figure 3.3.2. One or two people were allocated to a station on each day visited and each station was visited simultaneously twice a week starting at 5 o'clock and ending at half past 6 in the evening. Each observation of either blue-throated macaw or blue and yellow macaw was noted along with the time, numbers of individuals and direction of flight. Any other noteworthy observations were also recorded.



Station	G.P.S Point
1	S13°45.491', W066°07.186'
2	S13°45.870', W066°06.990'
3a	S13°45.491', W066°07.186'
3b	S13°45.297', W066°06.800'

**Figure 3.3.2** *Locations of the point count surveys in the Barba Azul Nature Reserve and corresponding G.P.S points. 3a = indicates the G.P.S point for this station utilised in the first 3 days of data collection, 3b = indicates the point utilised in subsequent surveys.*

In selecting the most suitable monitoring method for measuring abundance the use of other methods of population sampling such as capture-mark-recapture were considered, but were not used due to the small numbers of birds within the population and the high disturbance this method would have involved. It was decided that to reduce any physical impact on the natural behaviour of blue-throated macaw and blue and yellow macaw the studies should be conducted by counting the individuals as precisely as possible from a distance where behaviour was still able to be recorded. In order to reduce the chances of interfering with their natural behaviour, a man-made hide was used in order to conceal the observers if the viewing point was extremely exposed. Both Island surveys and point counts were usually conducted by 1-2 observers. Given the open view across the savannah and the visibility of flying birds the number of observers appeared to have little impact on how many birds were detected. Considerable care was taken in identifying each individual in order to achieve accurate results.

As it is likely additional birds flew away from the main island between the areas observed by the point counts and possibly during other times of the day out with the observation time, the figures represent the minimum number of individuals using the reserve on each survey day.

## Habitat and Ecological Surveys

Each island used in the project was surveyed to gather data on their dimensions in order to estimate the total area of the island. This was achieved by recording the northern, southern, eastern and western G.P.S points on the edge of the islands and central G.P.S points. The majority of the islands were roughly circular therefore, their area was calculated with the equation:  $Area = \pi r^2$ . There was only one island which was recognisably not of this shape This island was shaped like an isosceles triangle, therefore its area was calculated by the equation  $Area = \frac{1}{2}(base \times height)$ .

The islands were also visited by a botanist to aid in the identification of the main tree species in the island that the macaws utilised. Botanical data collected included identification of the main species of tree and whether the trees had fruits present on them. Samples of trees that were unidentifiable were collected so they could be brought back to the Museo de Historia Natural Noel Kempff Mercado in Santa Cruz and correctly identified in the laboratories there.

## Data Analysis

The raw data collected from the project was organised in Microsoft Excel 2003. The creation of the tables and graphs were also done on Microsoft Excel 2003. The programme MiniTab 14 was used to preform statistical analysis of the data

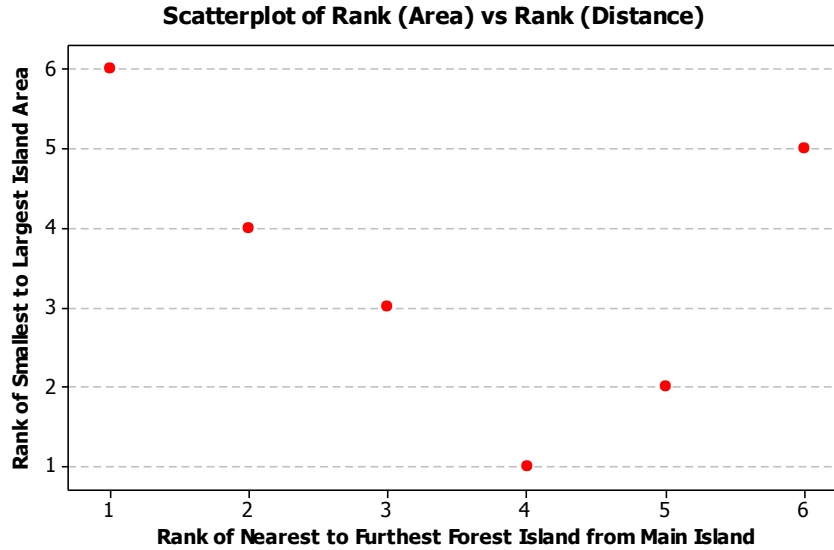
# 3.4 Results

## Island Surveys

A total of 30 island surveys were used in the analysis. The overall result from island surveys showed that the tendency for blue-throated macaw to perch within the islands was rare. Also, no evidence was found of the blue-throated macaw feeding within the forests during the survey period as no fruits were present upon the Motacú palms within survey islands. Island 4 was the island where observers frequently noted large accumulations of blue-throated macaw. However, this island was not utilized as a roosting site over night by either the blue-throated or blue and yellow macaw.

A Spearman's Rank Correlation Coefficient and corresponding scatter plot (see Figure 3.4.1) were used to examine any relationship between the area of each island used in the island surveys and the distance of islands from the main forest island. No direct

relationship was apparent from the graphs and the Pearson product moment correlation coefficient confirmed this with  $r = -0.371$ .



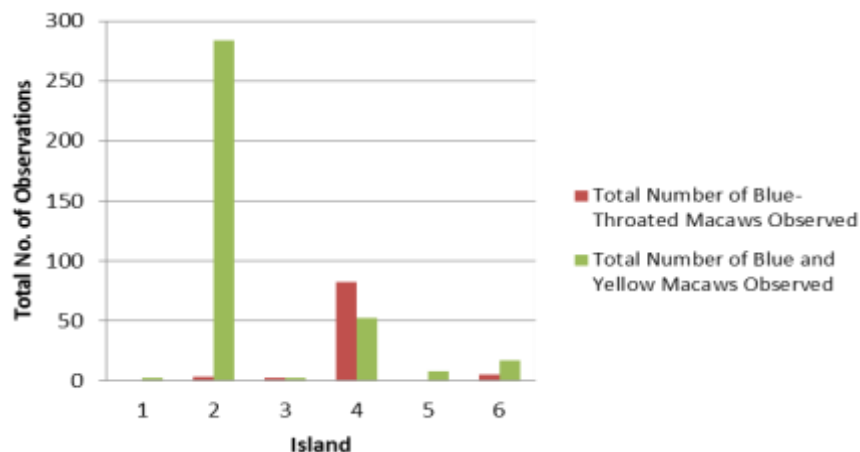
**Figure 3.4.1.** Scatter plot illustrating the relationship between the ranked data of each islands area (1= smallest, 6 = largest) and the distance of each island from the main island (1 = closest, 6 = furthest).

A Spearman's Rank Correlation Coefficient,  $r_s$ , was also calculated to assess any relationship between the numbers of observed blue-throated macaw in relation to either the distance of each survey forest island from the main island or the area of each survey forest island:

$$r_s(\text{number of individuals}_{\text{Blue-throated macaw}}, \text{distance}) = -0.058$$

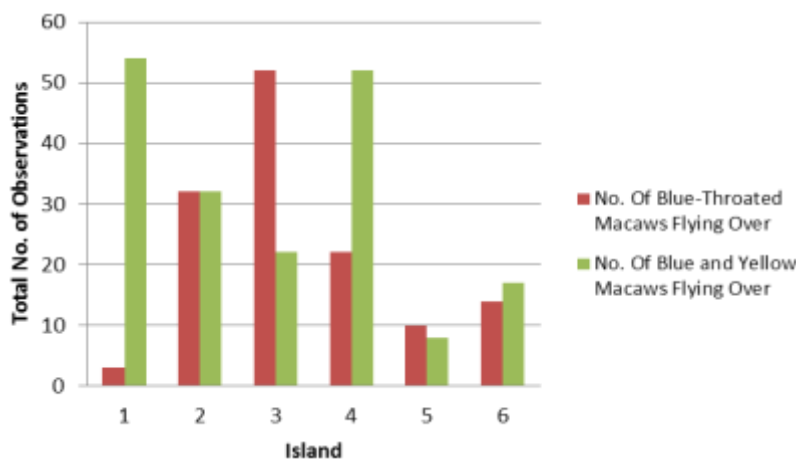
$$r_s(\text{number of individuals}_{\text{Blue-throated macaw}}, \text{area}) = -0.580$$

The level of significance for  $N = 6$  in a two-tailed test in relation to the critical values of Spearman's rank correlation coefficient equals 0.886. This value is not significant and therefore shows no relationship between the numbers of blue-throated macaw observed and the distance of the forest island from the main island or the area of the forest islands.



**Figure 3.4.2** *Frequency of individuals observed landing in the island. Numbers represent the total macaws observed landing in and remaining in the islands until the end of each daily survey for the whole survey period of 5 weeks .*

The total number of individuals observed actually landing in each island over the survey period and remaining in the island up to the end of the observational period is illustrated in figure 3.4.2. Low numbers of both species were recorded in islands 1, 3, 5, and 6. In Island 2, exceptionally high number of blue and yellow macaws landed and remained in the island with comparison to the others however, only 2 blue-throated macaws were observed to land on this island. Island 4 had a considerably larger number of blue-throated macaws landing in it with respect to other islands and was the only island where more blue-throated macaws (82) were observed than blue and yellow macaws (52).



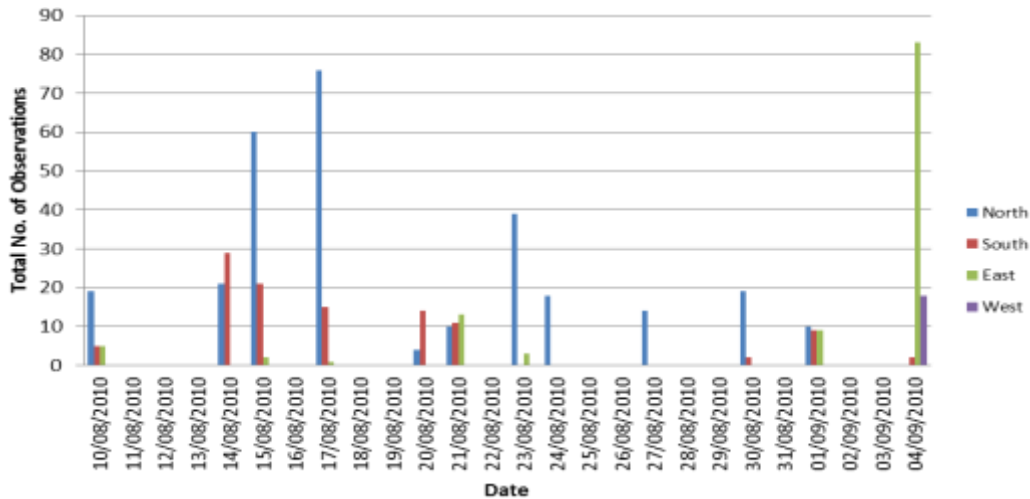
**Figure 3.4.3:** *Number of individuals observed flying over the islands without landing. Numbers represent the total macaws observed flying over the islands over the whole survey period of 5 weeks .*

For the whole survey period, the total number of individuals observed flying overhead was recorded in addition to the numbers of birds landing in the islands. Figure 3.4.3 shows that there was a large variance in the numbers of individuals recorded flying overhead between survey islands. Large numbers of blue and yellow macaws observed flying over island 1 but conversely, there were very few records of blue-throated Macaws here. Equal numbers of each species were observed at station 2. There were large numbers of both species flying overhead at islands 3 and 4, both of which are located close to the main forest island. Islands 5 and 6, located further away from the main island in the north of the reserve saw lower but similar numbers of blue-throated Macaws ( $N_{\text{Island 5}} = 10$ ,  $N_{\text{Island 6}} = 14$ ) and blue and yellow macaws ( $N_{\text{Island 5}} = 8$ ,  $N_{\text{Island 6}} = 17$ ).

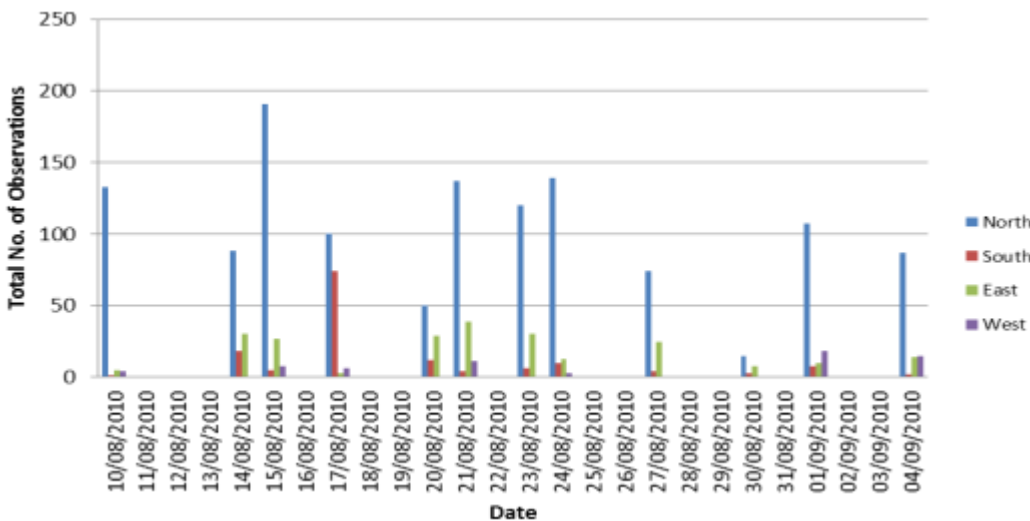
## Point Count Surveys

A total of 36 point count surveys were used in the analysis (3 points, surveyed twelve times). In total, 109 sightings of a group of one or more blue-throated macaw were achieved while 354 sightings of a group of one or more blue and yellow macaw were achieved. The majority of blue-throated macaw sightings consisted of pairs (41 of 109 sightings) or of small groups of between 3 and 6 (41 of 109 sightings). However, sightings of flocks of >6 individuals were not uncommon (13 of 109 sightings). For the blue-throated macaw, the largest flock recorded departing from the main island consisted of 58 individuals and the largest number of separate individuals recorded leaving the island on any one day was 103 individuals. As no individuals were recorded flying toward the island at this time of day the latter figure represents the minimum number of individuals that could be using the reserve.

Visual observation of raw data from point count surveys suggest that for both the blue-throated macaw and the blue and yellow macaw, the vast majority of individuals are flying in a northerly direction away from the forest island at pre-roosting time. Figures 3.4.4 and 3.4.5 highlight this trend. Northerly directions include ranges between north-west and north-east and southerly directions include ranges south-east and south-west.



**Figure 3.4.4** Daily directional movement of Blue-throated macaw from the main island during the point counts.

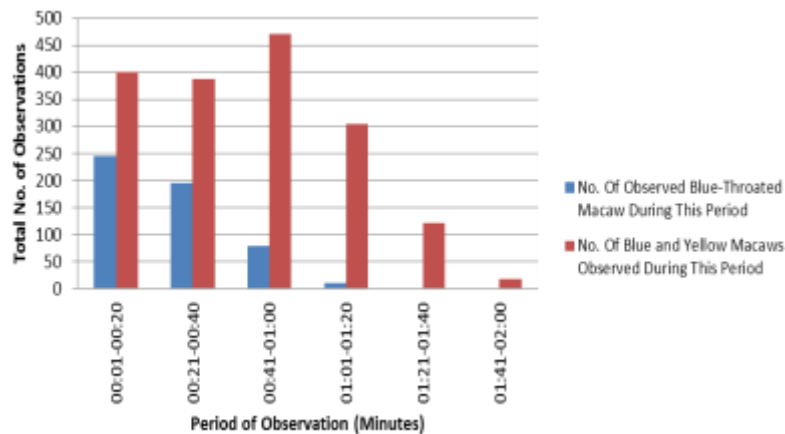


**Figure 3.4.5** Daily directional movement of *A. ararauna* from the main island during the point counts.

From personal observations, there appeared to be a tendency for the blue-throated macaw to depart the main island earlier than the blue and yellow macaw by approximately 1 hour. In contrast, blue and yellow macaw seemed to continue to depart from the main forest island much later than the blue throat. However, in both species, the numbers of macaws observed tended to drop off over time.

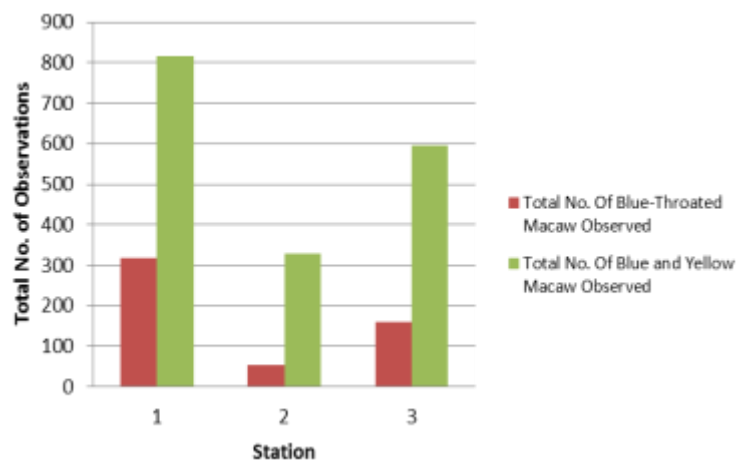
In this analysis, all blue-throated macaw observations (N = 532) and blue and yellow macaw observations over the whole survey period were used. These figures are not intended to represent the blue-throat population, but instead, to represent the significance

of departure time in relation to abundance. Each survey period for each individual survey point count was divided into intervals of 20 minutes in length from the time at which the first sighting of either species was recorded at that location. Figure 3.4.6 shows the cumulative number of each species recorded over six time intervals from the first sighting of each species at each point. Most blue-throated macaw observations were recorded between 00:00 minutes and 00:20 minutes. The number of observations within each time period appears to decrease as the length of time increases in accordance with the fore-mentioned observations. Additionally as the number of blue-throated macaw observations starts high and drops off, there is some evidence to support that the peak time of blue-throated macaw departure could be much earlier than our surveys began.



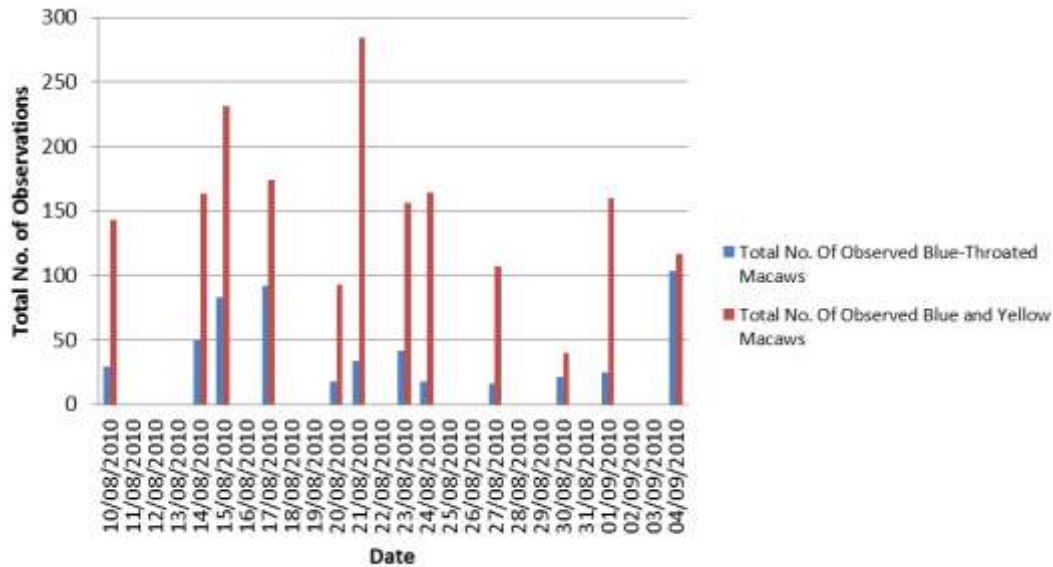
**Figure 3.4.6** *Number of individuals recorded during in intervals of 19 minutes*

The majority of blue throated macaw sightings were recorded at station 1 followed by station 3 then station 2. This pattern was also observed for the blue and yellow macaw (Figure 3.4.8).



**Figure 3.4.8** *Total number of observed individuals recorded during the point counts.*

Overall the results confirm that there are a larger number of blue and yellow macaws using the Barba Azul Nature Reserve than there are blue throated macaws. Despite the fact that the number of observations for each species fluctuates on a daily basis and from place to place, we can say with some level of certainty that the minimum number of blue-throated macaw using the reserve is 103 and also that the minimum number of blue and yellow macaws using the reserve is 284. (See Figure 3.4.9)



**Figure 3.4.9** *Total number of observed Blue-Throated Macaws and Blue and Yellow Macaws during the point count surveys.*

All the observations were taken from within the Barba Azul Nature Reserve as we did not have permission from the neighbouring ranch owners to have access to their land. It was however evident to the South on the other side of the river, the neighbouring ranch of ‘Juvena’ that there were significant numbers of macaws in that vicinity. However, it was not possible to tell whether the macaws on the other side of the river were blue-throated or blue and yellow due to their distance.

## Behavioral Observation

There were only a few instances where notable behaviour was observed, whether it was inter-specific or intra-specific. Blue-throated macaws and blue and yellow macaws were noted interacting on a couple of occasions. The first was on the 10/08/2010 at 17:31 during a point count survey at station 3 and the far end of the main island when a mixed flock of three blue-throated and seven blue and yellow macaws were observed flying away from the main island.

Further, at station 2 on 24/08/2010 various behavioural observations were made. Firstly, 10 blue-throated macaws were observed at 17:21 continually taking off and landing at the edges of the main forest island before their eventual departure to the north. During this period they also flew down to the river edge and some individuals were observed drinking beside a group of blue and yellow macaw which was also observed circling around the river and landing to drink from it. Although the two groups of macaws were observed mixing together it was noted that the blue-throated macaws seemed discouraged to drink when members of the blue and yellow group were in immediate proximity to them.

A second pair of blue-throated macaws was observed at the river edge during this point count at around 17:51. However, this pair kept their distance from the group of Blue and Yellow Macaws.

## Island Habitat and Ecology

Each island utilized as a pre-roosting survey site was assessed for botanical features and dimensions. Island 1 was the largest estimated at 21642m<sup>2</sup> and the smallest was island 2 estimated at 1256m<sup>2</sup> as shown in table 6. The only island which was not circular in shape was island 4, which was instead, more triangular.

Island	Area (m <sup>2</sup> )	Circumference (m)
1	21642	510
2	1256	175
3	4778	291
4	5008	387
5	5281	144
6	4301	232

**Table 3.4.3** *Calculated area for each forest island studied in the island surveys and circumference.*

Aquilino Molino (expedition botanist), noted that the floral composition of each island was similar. The islands were dominated by the Motacú palm species (*A. phalerata*) but no fruits were present upon any of these trees in any of the islands at the time of study. However, old fallen nuts were visible on the floor of the islands. Some of these discarded old nuts showed evidence of being eaten by both macaw species. As described by Yamashita *et al* (1997), blue-throated macaw consume the mesocarp layer of the Motacú palm nut by puncturing the apex of the nut and removing its outer layer before scraping and consuming the mesocarp latitudinally across the nut as shown in picture 3.4.1.



**Picture 3.4.1:** *The Motacú palm nut. Left: shows the mesocarp layer scraped latitudinally by the blue-throated macaw and Right: an uneaten specimen.*

Only the ecology of island 4 proved to be different from the other 5 islands used in the island surveys. It was evident that on island 4 *A. phalerata* was not present. The trees within the island were sparsely distributed and upon identification by the botanist the tree, *Vochysia thyrsoidea*, dominated the centre of the island. This tree emerged higher above the canopy than any other tree in this island and was estimated between 12m and 15m in height. There was no indication of any fruits upon this tree, nor on any of the other trees within this island. Blue-throated macaws were observed on many occasions congregating in this tree during point count surveys at station 3. A nest box put up previously by Asociación Armonía was present on this tree however, there was no evidence of it being utilised by the macaws and it had become infested with termites.

## 3.5 Discussion

The first aim of this study was to estimate the abundance of blue-throated macaw within the Barba Azul Nature Reserve through point count surveys and island surveys and also

to collect data on their directional movement from the main forest islands out to the smaller forest islands and compare this to the abundance and movement of the sympatric blue and yellow macaw. In addition to this, the natural inter-specific behaviour between blue-throated macaw and the blue and yellow macaw during the island surveys and point count surveys was also recorded. This discussion examines these aims through the separate analysis of each observational type, island surveys and point counts, thus providing an up to date record of the status of *Blue-throated macaw* within the Barba Azul Nature Reserve.

The initial plan prior to arrival in the Barba Azul Nature Reserve was to carry out only the island surveys as a means for the abundance survey as it was presumed that *Blue-throated macaw* utilized the smaller forest islands within the reserve during the night as a roosting ground. It was soon realised that this method provided limited information on the populations so after one week of conducting the island surveys a second method of observation was introduced, the point count surveys. The point count surveys provided a more accurate record of the population of Blue-throated macaw within the reserve and the island surveys allowed for an analysis of the numbers of individuals utilizing the forest islands at nightfall.

## Island Surveys

Exploration of the reserve in the first week of the expedition enabled forest islands to be located where the blue-throated macaw was believed to roost. Some islands were also chosen even if it was unknown whether they were utilized by blue-throated macaw or not. Observation time was restricted to the pre-roosting period as this was when the birds tended to venture outwards from the main island and became notably more visible, audible and active.

From observations it is safe to conclude that blue-throated macaw do not utilise the smaller forest islands within the Barba Azul Nature Reserve to the extent that was expected. The project established that there are a large number of blue-throated macaws and blue and yellow macaws which utilize the main island in the day but do not reside in the smaller forest islands during the night. From the surveys conducted in the far north of the reserve at islands 5 and 6, flocks of blue-throated macaw and blue and yellow macaw were observed flying out-with the reserve to the north and into the 'Las Gamas' ranch or possibly even further afield.

In surveying the habitat of the islands none of the Motacú palms showed any sign of fruiting indicating that the macaws did not use these islands for feeding at the time of survey and that they probably exploited the main forest island for feeding purposes instead. However, scattered across the floor of the islands were old nuts which had fallen from the trees indicating that they had already fruited earlier in the year. This is in accordance with Barthlott *et al.* (1998) who states that the Motacú palm fruits early on in the dry season and in the onset of the wet season. In relation to this fact it would not be wise to rule out the possibility that these islands may be used for feeding or even roosting at different times of the year from when this project was conducted.

## Point Count Surveys

The points counts were conducted in areas where viewing capacity was maximal and the potential of overlapping observational ranges from the other points was small. This allowed for a more accurate population count. The stations were all positioned at points at approximately equal distances from one another around the main forest island allowing for a large geographical range. The original point for station 2 was approximately 200m from the main camp however, this point was relocated after 3 days to a point located a further 600m along due to the restriction to view caused by an out-crop of trees.

From visual analysis of the raw data on directional movements from all three of the point count stations, the vast majority of blue-throated macaw seemed to fly from the main forest island in a northerly direction. This is supported by the histograms depicting their directional movements (See Figures 3.4.4 and 3.4.5). The most logical reason explaining this direction of travel could be that, located towards the north of the reserve there are an abundance of smaller forest islands on the perimeter of the reserve and also further afield out into 'Las Gamas' ranch which may be used for roosting.

It was clear that station 1 (located at the most easterly point of the main forest island) yielded significantly higher numbers of blue-throated macaw sightings than any other station. This uneven distribution of blue-throated macaw sightings may be down to factors both biotic and abiotic within the forest island. For example the distribution of fruiting trees within the main island may have affected where the macaws were located or as most sightings were achieved at the point furthest from the main camp, perhaps the birds tend to avoid gathering near sites of human activity.

One very interesting observation which, to date, does not seem to have been mentioned in any other literature, is the suggestion of a difference in departure time between the species. It seemed that blue-throated macaw tend to depart from the main forest island before the blue and yellow macaw. On many occasions, blue-throated macaw left the main forest island approximately one hour prior to the blue and yellow. This behavior was especially apparent at station 1. Station 1 was a key position for observing intra-specific interactions and patterns in daily migratory behaviour. Station 1 was located in close proximity to island 4, used in the forest island surveys. Island 4 was only approximately 413m away from the main forest island and was also key site for behavioral observations. The *Vochysia thyrsoidea* tree was distinctively utilised by blue-throated macaws, which perched in its branches in the early evening. It was apparent that blue-throated macaw tended to fly from the main island in pairs or small groups of 3 to 4 individuals. However, these birds would often perch in island 4 and remain here until a large number would build up, with instances of up to 80 individuals being observed. After this, the flock would usually leave together, often upon the emergence of blue and yellow flocks from the main island, and travel away in the same direction as them.

Interestingly, *A. ararauna* did not utilise island 4 in the same manner, nor in the same frequency as *Blue-throated macaw*.

A final notable observation was that as the weather change from the normal hot and dry conditions, the number of observations of both blue throated and blue and yellow macaws notably decreased.

## **Behaviour**

Previous studies by Yamashita *et al.* (1997) and others have made notable references to inter-specific competition between the blue-throated and blue and yellow macaw. However, most of this behavior was recorded during the mating season and could be attributed to territorial disputes. This project was not conducted during the mating season and could be the reason no such interactions were observed.

Many observations in both the point count surveys and island surveys noted that both species commonly fly in pairs. Although it is not possible to distinguish between the sexes of either species because neither are sexually dimorphic, it could be that these pairs are male/female.

From reviewing the sparse literature on both the blue-throated and blue and yellow macaw, it would appear that there have never been instances recorded of the two species interacting yet in this project several instances were recorded of the two species departing from the main islands within the same flocks and instances where drinking from the River Omi occurred in close proximity.

## **Population**

According to Hesse *et al.* (2000) the populations recorded for the blue-throated macaw were extremely low between 1993 and 1999 and by extrapolation of the data in relation to suitable habitat area it was calculated that the population was 120 individuals. More recent estimates have put the global blue-throated macaw population at around 300 individuals. Since the maximum number of individual blue throated macaws observed in one point survey during this study was 103, this figure then represents the minimum number of individuals that are using the reserve. Thus it would seem that the Barba Azul Nature Reserve holds at least one third of the current estimated global population of blue-throated macaws, highlighting the reserves vital importance for the conservation of this critically endangered, endemic species.

## **Future Development Proposed**

The islands in which Blue-throated macaw reside in at night are now thought to be out-with the perimeter of the Barba Azul Nature Reserve at least at the time of year at which

this survey was conducted. However, accounts from the 2009 expedition indicate the possibility that the birds may have been using the reserve's smaller islands to roost in during that time. 2009 was a much wetter year so perhaps environmental differences can affect roost site choice, it would be interesting to resurvey the islands again annually to confirm these reports. It would also be interesting to examine the botanical and environmental qualities of known roost sites on nearby ranches in order to understand more about macaw roost site requirements. Permissions need to be sought in order to explore 'Las Gamas' ranch to the north of the reserve, 'Los Patos' to the north- west, 'Pelotal' to the west and 'Juan Latino' to the east in order to do this. With the purchase of the 'Juvena' ranch in September 2010 the prospects of further exploration of the blue-throated macaws habitat and conservation needs can be extended, hopefully allowing for a greater understanding of the current little known natural ecology of this critically endangered species.

From the research conducted in this project it was observed that on several occasions during the point count surveys flocks of blue-throated macaw departed from the main forest island toward 'Juvena' and could often be heard calling from across the river Omi until just before dark. This presents the possibility that these flocks may reside in the Juvena area over night. Thus it would be interesting for future study to investigate this region to confirm if the macaws roost there. A more in-depth understanding of blue-throated macaw ecology will allow the design of more intricate and specific projects and conservation strategies to preserve current populations and improve the prospects of future generations.

Within the reserve, research into how the blue-throated macaw utilizes gallery forest in comparison to the blue and yellow macaw during the day also needs to be explored further. Daytime behavioral surveys could also be beneficial in increasing our knowledge of the species.

In accordance with Hesse *et al.* (2000) and findings from Motacú palm nuts in the reserve, there is a notable difference in the method of consumption of the mesocarp layer between the blue-throated and blue and yellow macaw. In discovering consumed fallen nuts within the forest it may be possible to decipher whether feeding grounds are present and if these grounds are specific to a species or if they are shared.

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## 4. Nightjar Survey:

# Nightjar diversity survey and the search for the endangered white-winged nightjar (*Eleothreptus candicans*)

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Kirsty Godsman

## 4.1. Introduction

The White-winged Nightjar (*Eleothreptus candicans*, previously known *Caprimulgus candicans*) is listed as Endangered by the IUCN (IUCN 2011). This is thought to be due to its small known range and destruction and degradation of its habitat (Pople 2003). One of the four areas where it has been recorded is Beni Biological Station, in the same regional department as the Barba Azul Reserve (Pople 2003). Here, it is known to use open grasslands including, campo cerrados and campo limpos where there are termite mounds and areas of younger vegetation for foraging and nuptial displays (Pople 2003; Birdlife 2011). Since the Barba Azul reserve contains these habitat types, it was considered feasible that the white-winged nightjar also exists here. Additionally, there was one suspected sighting of the species during the Glasgow University Bolivia Expedition 2009. However, this sighting awaits confirmation.

## 4.2. Aims

This study aimed to establish if the endangered White-winged Nightjar was present on the reserve via night-time visual encounter surveys (VES) and, if so, to map its distribution in the savannah habitat, conduct line transects to allow estimation of population size and density and further conduct assessments of habitat use via botanical assessments.

While searching for the species we were also able to compile an inventory of other nightjar species using the Reserva Barba Azul.

## 4.3. Methods

Evening VES transects were conducted in conjunction with mammal line transects to allow us to survey the reserve for the presence of the White-winged Nightjar. These were carried out roughly every second night, when there were enough personnel and a different route was taken each time.

In order to identify species, powerful torches were used to scan for eye shine or for birds in flight over the transect line. If a bird was spotted, we would quietly move closer until we were able to positively identify the species. Species, sex (if possible), time and position were recorded.

## 4.4. Results

In total, five species of Nightjar were identified (See Table 4.4.1 and Figures 4.4.1 – 4.4.5) over the 35 days in the reserve. No White-winged Nightjars were found during this time. Since no White-winged Nightjars were found, there was no assessment of habitat use. The relative abundance of species sightings is shown in figure 4.4.6. The scissor-tailed nightjar appeared to be the most common species observed. Other species were observed in similar but much lower numbers. The little nightjar was the least commonly observed nightjar species.

Common Name	Species	No. of Detections
scissor-tailed nightjar	<i>H. torquata</i>	58
maculosa nighthawk	<i>P. maculosa</i>	9
common potoo	<i>N. griseus</i>	6
little nightjar	<i>C. parvulus</i>	2
common pauraque	<i>N. albicollis</i>	7
Total	5	82

**Table 4.4.1:** Nightjar species list for the Reserva Barba Azul. Indicates the total species found and the total number of detections for each species.



**Figure 4.4.1:** Adult male scissor-tailed nightjar (*Hydropsalis torquata*).



**Figure 4.4.2:** Adult female scissor-tailed nightjar (*Hydropsalis torquata*)



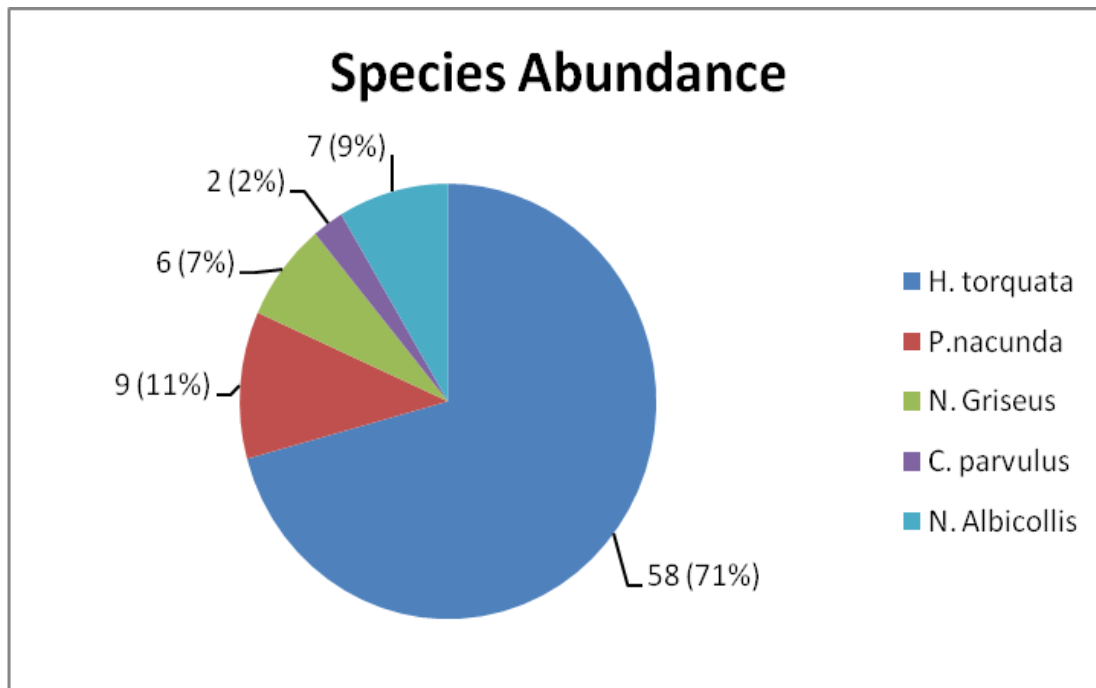
**Figure 4.4.3:** The common Pootoo (*Nyctibius griseus*)



**Figure 4.4.4:** *The little nightjar (Caprimulgus parvulus)*



**Figure 4.4.5:** *The common pauraque (Nyctidromus albicollis)*



**Figure 4.6:** Pie chart of relative species abundance of Nightjars identified in the Barba Azul Reserve. Units are number of detections and, in brackets, percentage of total number of detections.

## 4.5. Discussion

A number of nightjars were identified within the reserve but the white-winged nightjar was, unfortunately, not amongst them. This may have been expected since despite the thought that the species was present in the nearby Beni Biological Station, further investigation found that there has actually only ever been one confirmed sighting in the station and that this was in 1987 (Pople 2003). However, the habitat requirements of the white-winged nightjar as outlined by Pople (2003) suggest that The Reserva Barba Azul provides ideal habitat for the species. White-winged nightjars require campo cerrados and grasslands containing a mixture of younger vegetation for foraging, intermediate-aged vegetation for cover and low and broad termite or ant mounds for male nuptial displays. Females are known to nest directly on the ground and, for this, require campo cerrado or wet grassland vegetation in patches next to small clearings which they use as an escape route to fly away when disturbed (Pople, 2003).

The main reason that white-winged nightjars may not have been observed, if they are in fact present, could be that the study was carried out from July to the beginning of September. This species is known to become more active from the end of August until January (Pople 2003). During this period, males defend small, aggregated territories on

which they perform nuptial display flights and produce a mechanical noise display described as a tuc trrrut noise (Pople, 2003). The aggregated nature of these leks or landmarks, and the fact that females regularly visit them for the purpose of mating (Pople, 2003), mean that it could be much easier to observe these birds during their breeding season. The timing of these behaviors are thought quite predictable: white-winged nightjar breeding behavior has been found to be well correlated with full moons and displays usually begin at dusk on cloudless nights (Pople, 2003). This information could make it possible to carry out a survey that is more successful in finding this species.

Given that the Barba Azul reserve seems like such ideal habitat for White-winged Nightjars, it could be recommended that further investigations are carried out to see if the species is present in the reserve. If further study was carried out, it would be recommended that investigatory trips were made throughout the reserve, prior to night time VES to identify areas in which the white-winged nightjar may be more likely found. This will make it easier to include such areas in night time VES so that it can be either confirmed or ruled out with confidence that this species is present.

It would be great news if White-winged Nightjars were found in the Barba Azul reserve as this area is now free from the activities that threaten them elsewhere such as cattle grazing and forestation and they could prosper..

## 4.5. References

**Pople, R. G. (2003)** The Ecology and Conservation of the White-winged Nightjar *Caprimulgus candicans*. Queens College.

**IUCN (2011)** Red List of Threatened Species: *Eleothreptus candicans* (White-winged Nightjar) <http://www.iucnredlist.org/apps/redlist/details/143386/0>

Bird Life (2011) Bird Life International, species fact sheet: White-winged Nightjar (*Eleothreptus candicans*) <http://www.birdlife.org/datazone/speciesfactsheet.php?id=2390>

## 5. Mammal Report: Minimum Abundances of Key Species and Diversity

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Duncan McNeil

## 5.1. Introduction

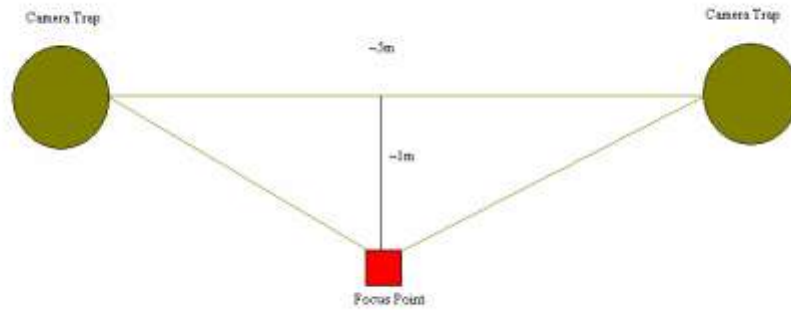
The mammals of the Barba Azul reserve play an important role within the Beni savannah ecosystem, in conservation of the Beni Savannahs and also in global conservation in general. The reserve itself acts as a safe haven for mammal species within the intensely hunted and highly modified surrounding savannah ecosystem, a factor which has been aided by the recovery of the habitat within the reserve since its purchase in 2008. Since then both local researchers and students from the Glasgow University Bolivia Expeditions have noticed an increase in mammal detections within the reserve. However, more work still needs to be done to protect these animals and to allow their populations to flourish. This is especially true for species with large ranges such as the near threatened jaguar and maned wolf. Animals such as these often require extra consideration from conservationists due to their capabilities and tendency to travel vast distances. For example the maned wolf typically has a home range of 39-58km<sup>2</sup> per adult pair and the jaguar can typically range approximately 25-70km<sup>2</sup>. (Trolle Et. Al. 2007, Silver Et. Al. 2004) As the Barba Azul reserve only stretches over an area of 35.5km<sup>2</sup> it is unlikely to hold more than one adult pair of each of these species, a theory which is supported by the data gathered from within the reserve. While this is still a reasonable conservation effort this indicates that the ongoing expansion of the reserve and links to other areas of intact habitat is imperative to the survival of these very charismatic species within the Beni Savannahs.

This year, the expedition also began catalogue of small mammals and bats on the Barba Azul reserve through placing Sherman traps and conducting mist netting in a variety of habitats within the reserve. This will allow us to further increase the species list for the area, although it is likely that more sampling effort will be needed in order to get a complete list. Unfortunately at present we do not have any data available on the bat and small mammal studies as we are still awaiting a full report from our local mammal expert Luis Hernan Acosta Salvatierra. However, this data shall be translated and made available as soon as we receive it.

## 5.3. Methods

### Camera Trapping

Over the course of the expedition 13 camera trap stations were erected within the reserve at a variety of locations. The locations were chosen in areas where high mammal activity was expected, near watering holes, along game trails or in areas there were large numbers of recent tracks or scats were observed. Care was also taken to monitor the savannah habitat specifically but also to include the other habitats within the reserve.



**Figure 5.2.1:** *Arrangement of camera traps at camera trap stations.*

To set the camera trap stations a pair of traps were set at approximately 50cm from the ground either on a tree or on posts placed by the team. The traps were set approximately a few meters apart facing a central focal point in order to capture photos of both sides of any animals recorded in order to allow more accurate identification of individuals (See (Figure 5.2.1). After mounting the traps, vegetation was cleared from within the line of the lens so as to minimize the possibility of the camera triggering accidentally when not needed. The traps were then placed on a 30 second delay between pictures and left. As camera traps are most effective when the disturbance around them is minimized, once set they were avoided for the duration of the study except for routine maintenance checks.

## Transects

Transects were conducted daily into the savannah, these commenced at 200m intervals along the breadth of the reserve, giving 15 parallel transects, and 6 more were conducted deeper into the savannah. All transects were 1.3km long and walked by 2 people in the exact same direction, ensured using a compass. Each of these 21 transects were walked twice within the expedition, the order in which to do them drawn from a lottery. Each transect lasted approximately 2.5 hours, starting at sunrise, and all mammals seen were recorded, including a GPS location and distance from transect.

As well as this night transects were conducted, these began approximately 30 minutes before sun set and were always walked by 2-3 people for safety. Transects varied in location in order to record a variety of species. Night transects were not limited in distance however as a general rule they lasted 1-1.5 hours dependant on conditions.

## Small Mammals

Over the course of the expedition 3 transects were constructed, in the forest, cerrado and savannah, each of these was active for a week. At 25m intervals a pair of Sherman traps were placed, one 5m from either side of the track. These were set and baited with a variety of scented oat mixes to attract animals. To ensure welfare traps were placed in the

shade and checked regularly when set. Any animals caught were collected by Luis Hernán Acosta Salvatierra for identification.

## Bats

The bat study was conducted by Luis Hernán Acosta Salvatierra it was based in 5 locations in a variety of habitats throughout the reserve including the forest, savannah and cerrado. At each site 5 strips were cleared in areas deemed likely to contain a lot of bats, such as natural corridors, in each of these strips a mist net was erected. Where possible 2 of the 5 nets were raised in trees so that they were 6-8 meters off the ground, this was hoped to allow capture of a slightly more diverse range of species. Each night the nets were open for approximately 5 hours and checked at 20 minute intervals to ensure no individual was left in the net for any great length of time. All bats caught were photographed and identified by Luis.

## 5.4. Results

From camera traps, line transects and casual sightings, we detected the presence of a total of 20 large mammal species within the reserve, these species are shown in table 5.3.1. Using camera trap data, minimum numbers of individuals for target mammal species were estimated. This was achieved by comparing the identifying marks of different individuals such as scars and fur markings. The results of this analysis have also been indicated in table 5.3.1 as has the presence of juveniles with any of any observed species. Two individual maned wolves, *Chrysocyon brachyurus*, were recorded on a number of occasions. These were easily identifiable as distinct individuals as one was missing its tail (See mammal report title page). A minimum of 5 giant ant eaters, including one infant, were observed during the study. The identifying features of these are shown in fig.5.3.1. One female puma and cub were recorded separately but during the same time series on one camera and another larger individual, thought to be a male was recorded on a separate occasion (See figure 5.3.2. a-c). Hence a minimum 3 pumas are thought to be using the reserve. Fur markings allowed identification of 3 separate ocelot individuals using the reserve (See Figure 5.3.3.) and antler shape differences allowed us to identify at least 6 individual pampas deer (See Figure 5.3.4).

Species	Scientific name	Minimum number of individuals	Juveniles observed
Puma	<i>Puma concolour</i>	3	Y
Jaguar	<i>Pantera onca</i>	1	N
Maned wolf	<i>Chrysocyon brachyurus</i>	2	N
Giant ant eater	<i>Myrmecophaga</i>	5	Y

	<i>tridactyla</i>		
Ocelot	<i>Leopardus pardalis</i>	3	N
Jaguarundi	<i>Puma yagouaroundi</i>	1	N
Short eared dog	<i>Atelocynus microtis</i>	4	Y
Pampas deer	<i>Ozotoceros bezoarticus</i>	6	Y
Crab eating fox	<i>Cerdocyon thous</i>	N/A	N
Crab eating raccoon	<i>Procyon cancrivorus</i>	N/A	Y
Black howler monkey	<i>Alouatta caraya</i>	N/A	Y
Brown Agouti	<i>Dasyprocta variegata</i>	N/A	N
Capybara	<i>Hydrocaeris hydrocaeris</i>	N/A	Y
Yellow armadillo	<i>Euphractus sexcinctus</i>	N/A	N
Nine banded armadillo	<i>Dasytus novemcinctu</i>	N/A	N
Collared peccary	<i>Pecari tajacu</i>	N/A	N
Common Opossum	<i>Didelphis marsupialis</i>	N/A	N
South American coati	<i>Nasua nasua</i>	N/A	N
Southern tamandua	<i>Tamandua tetradactyla</i>	N/A	Y
Brazilian porcupine	<i>Coendou prehensilis</i>	N/A	N

**Table 5.3.1:** Mammal species list from camera trap, transect and casual sighting data for the 2010 expedition showing the minimum number of individuals estimated from camera trap photos. Species for which we were unable to identify the minimum individuals are marked N/A. Those species with which juveniles were observed are indicated.



**Figure 5.3.1:** *The identifying features of giant anteater individuals photographed within the Reserva Barba Azul Note the juvenile on the female bottom right.*

a)



b)



c)

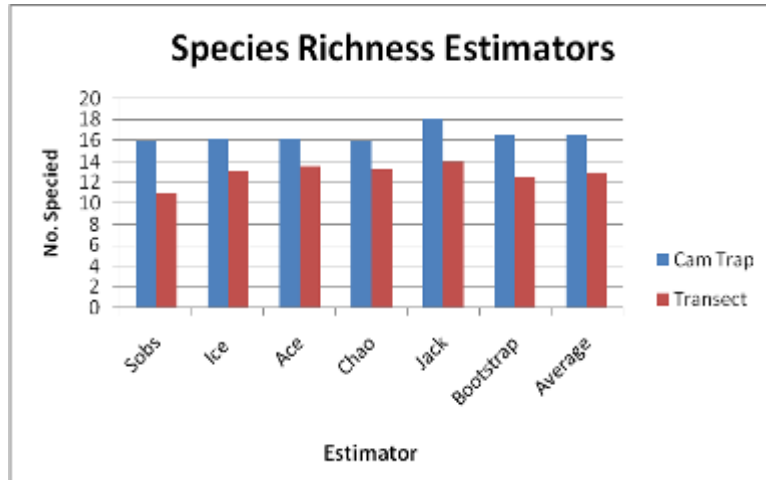


**Figure 5.3.2 a-c:** Separate puma (*Puma concolor*) individuals recorded on camera traps within the Reserva Barba Azul. a) Adult female b) Cub of adult female shown in (a) c) Possibly an adult male.



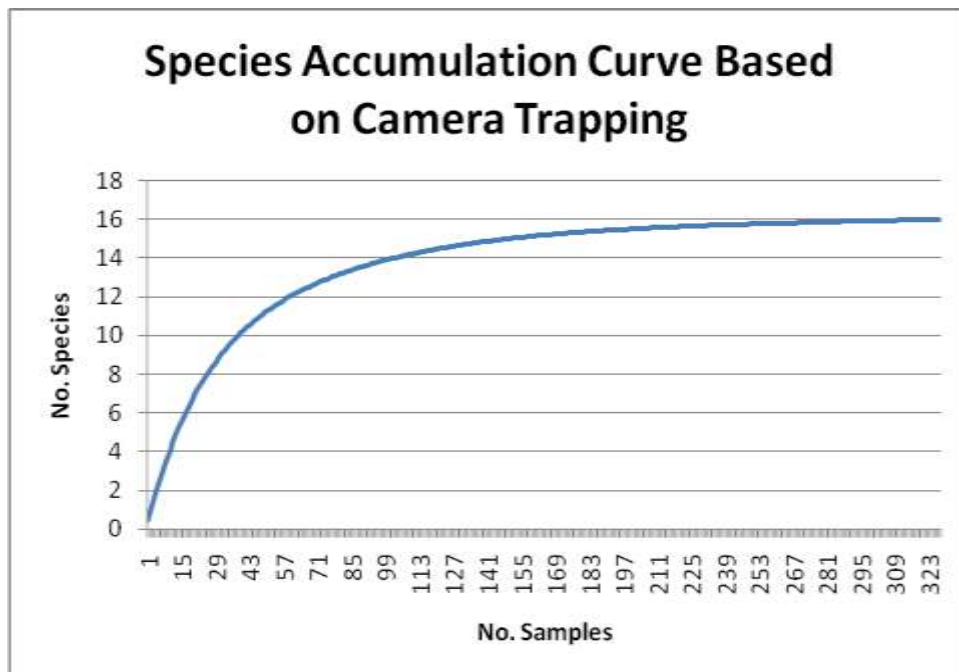
**Figure 5.3.3:** One of the three ocelot (*Leopardus pardalis*) individuals detected for the reserve

Both camera trap and night transect data (No mammals were recorded on morning transects) were compiled and run through Estimate S in order establish species richness estimators for the reserves large mammal fauna. These are detailed in the following figures 5.4.4 – 5.4.5 a-b:

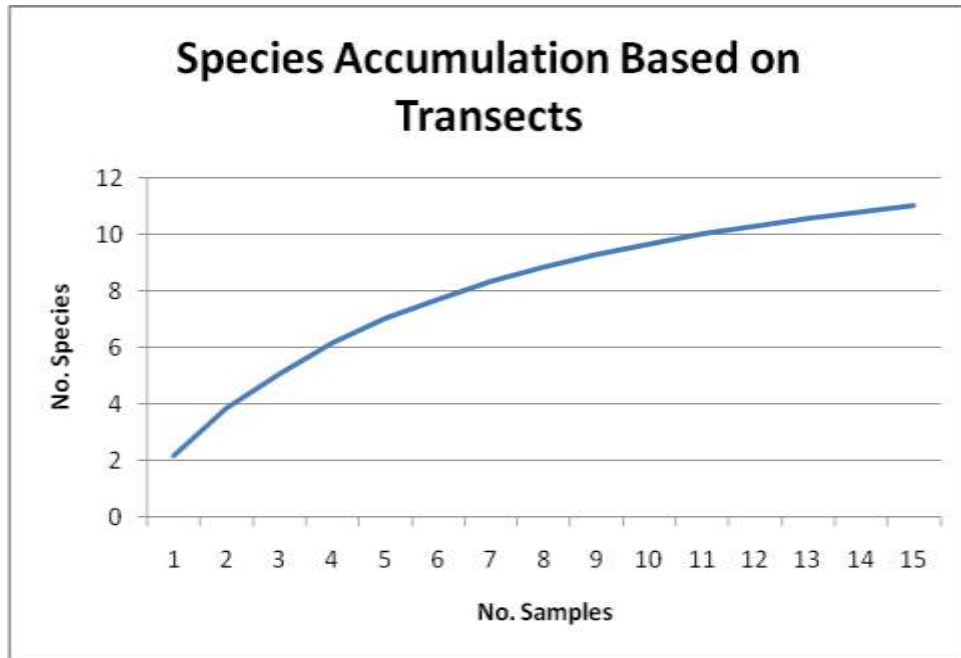


**Fig. 5.3.4:** *Species richness estimators from Estimate S. Comparative for camera trap and transect data.*

a)



b)



**Figure 5.3.5 a-b:** *Species accumulation curves for mammals in the Barba Azul reserve. a) Data for camera trapping. b) Data from night transects. Both (a) and (b) are based on SOBS value provided by Estimate S*

Included in the data collected was information on the casual sightings made by the team throughout the expedition, summary data for key species can be seen in table 5.4.2. In this case casual sightings do also add some species to the total for the area including the Jaguarondi and Brazilian Porcupine.

Species	Scientific Name	No. of sightings	Average group size	Max Group size	% days seen
Maned wolf	<i>Chrysocyon brachyurus</i>	1	1	1	1.6
Giant ant eater	<i>Myrmecophaga tridactyla</i>	6	1	1	6.4
Pampas deer	<i>Ozotoceros bezoarticus</i>	9	1.556	3	14.4
Jaguarundi	<i>Puma yagouaroundi</i>	1	1	1	1.6
Puma	<i>Puma concolour</i>	1	2	2	1.6
Brazilian porcupine	<i>Coendou prehensilis</i>	1	1	1	1.6
Short eared dog	<i>Atelocynus microtis</i>	1	1	1	1.6

**Table 5.3.2:** *Casual mammal sightings on the Barba Azul reserve.*

It can be seen from this that by far the most common sighting was of the Pampas deer, with at least 9 sightings throughout the expedition, it also shows that a number of species such as the jaguarundi and maned wolf were extremely unusual sightings, with only one direct visual sighting of each. This suggests that these are relatively scarce within the reserve but were also noted as being rather timid which may have reduced the likelihood of an encounter.

We are currently awaiting a report from our mammal specialist Luis Hernán Acosta Salvatierra containing the full results of the small mammal and bat studies; these shall be translated and made available as soon as we receive them.

## 5.5. Discussion

Camera traps seem more effective at capturing a higher diversity of species. This probably due to a number of factors, the reserve itself is very flat, and people can be seen from quite a distance, therefore it is possible that people walking transects may have scared animals away. The camera traps themselves are also excellent tools, running 24 hours a day and relatively sensitive and disturbance limiting (throughout the expedition close to 2000 photos of animals were taken by camera traps). They were able to capture some of the more elusive animals of the reserve such as puma, maned wolf and ocelot which had not been captured on camera during the 2009 Glasgow University Survey.

A few issues with camera trap reliability did arise. There were a few occasions in which only one of the pair of cameras functioned properly or flash interference reduced the

quality of photos, this meant that definite identification of individuals was sometimes impossible or difficult possibly reducing minimum numbers of key species. In future this hazard could be reduced by mounting traps more securely and so that they are more angled to a central point.

Towards the end of the expedition there were also a few issues with mist in the savannah, this steamed up the viewfinder and obscured some photos, most importantly 6 photos of the maned wolf, this again made identification impossible and may also have reduced the total count of individuals. However due to the generally low densities of this animal described in relevant literature, typically 3.64 per 100km<sup>2</sup> the likelihood of having more than two individuals on the reserve is slim (Trolle *et al* 2007). Thus it is likely that our estimate of only one pair for the reserve is reasonable.

It is also possible that there are mammal species on the reserve not recorded by camera traps due to their small size not triggering the sensor (we have noted that nothing smaller than an armadillo was ever recorded). However, it is hoped that these species shall be accounted for in the small mammal study.

It can be seen from figure 5.3.4 that almost all species richness estimators predict close to 16 mammal species might be detected by each survey method. Slightly more, a total of 20 species, were recorded in total via camera traps, transects and casual sightings, and it suggests our sampling within the reserve was adequate to identify all the large species present in the monitored area of the reserve at time of survey. For logistic reasons only one end of the reserve was sampled intensely by the team so a lack of data for the north end of the reserve may have some influence in the final outcome of results. It would be recommended that in future surveys, this imbalance should be rectified so that sampling effort is more even across the reserve. It is also worth noting that while track and scat evidence was noted throughout the expedition this has not been included in the analysis, this is because it was only occasionally recorded and gives no added value to the results of new species for the list.

Team members who had worked on the reserve in 2009 and local guides and researches encountered by the team this year reported noticing a pronounced increase in the number of some species observed within the reserve, specifically giant anteaters, ocelot, puma and pampas deer. Also only two individual giant anteaters were identified from camera trap data in 2009 (Reekie 2010) compared with 5 this year and no ocelot or puma were directly observed in 2009 but this year we were able to capture images of more than one individual of both species on camera traps. The protection of the reserve may therefore be driving an increase in species numbers. The data achieved here will allow monitoring of this effect in future expeditions.

A number of juvenile mammals on the reserve were also noted this year, with sightings of juveniles for 8 of the 20 species observed. Again, this may be due to the fact that the reserve has become a safe haven of regenerating habitat surrounded by damaged and dangerous farmland where local ranchers are known to hunt a number of species. Protection from such pressures on the reserve may have prompted the movement of some

individuals into the reserve. Also, the number of juvenile animals found on the reserve indicates mammal populations within the reserve are beginning to recover and provides strong evidence of the reserves positive impact on the conservation of these species.

The occurrence of more large predatory big cats noted this year may also indicate that habitat regeneration and reserve protection are having a positive effect on the restoration of species assemblages and trophic interactions.

It is also worth mentioning that despite efforts to remove cattle from the land, a large number of agricultural animals are still gaining access to the reserve. On one occasion, close to 200 cows were encountered in the reserve. While these are comparatively low numbers in relation to the neighboring ranches, having such large herds of large grazing animals must undoubtedly have some effect on the reserves ecology. Also, due to the aggressive behavior exhibited by these cows in response to humans, it could be possible that such herds could also move other mammals out of their normal ranges or force to alter their natural behaviors.

## 5.5 References

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