Glasgow University Bolivia Expedition Report 2012

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

Giant Anteater at sunset (photo by Jo Kingsbury)

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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.*

Written by Jo Kingsbury

Bolivia

Figure 1.2: *Map of Bolivia in South America*

Spanning an area of 1,098,581km², 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. 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 "mega-diverse" 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 (Gonzales and Reichle 2003). Further, more than 20 000 plant species exist within its frontiers, ranking it around 10th 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 Seasonally Flooded Beni Savannahs

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^2. The ecosystem is endemic to Bolivia & considered critically endangered by The Nature Conservancy. Historically, a lack of technological advancement, coupled with reduced accessibility has afforded preservation of astonishing biodiversity in the remote region (Ibisch 2005) with records including: 509 bird species, 146 mammal species and more than 5000 species of plant (Beck & Moraes 1997). Further, considering the significant lack of research conducted on the regions biota to date, it is believed there may still be much to uncover regarding its diversity (Langstroth (in press)). At present, almost all land in the region is privately ranched with no restrictions on purchasing property. Additionally, the savannahs remain almost entirely unprotected by conservation agencies. There is, therefore, warranted concern that the Beni's natural flora and fauna may currently be experiencing extreme pressure from the impacts of cattle ranching. The government has already ruled out the possibility of extending its network of national parks, (Ibisch 2005) and it is likely that all further conservation effort will take the form of private reserves.

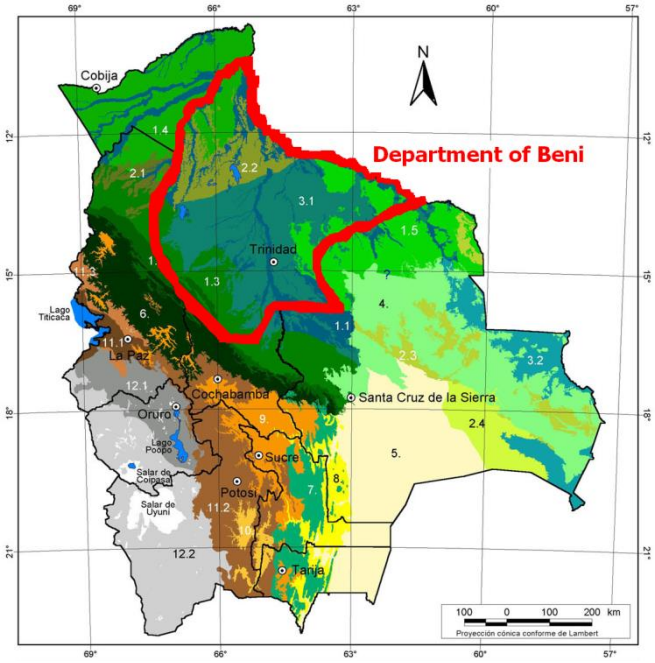

Figure 1.3: *Map of the Beni Department, Bolivia. Map indicates the departmental capital Trinidad*

The Beni region is composed of a savannah-mosaic landscape, known locally as the "Llanos de Moxos Floodplains". The plains are characterized by extensive, low-laying seasonally flooded savannah grasslands interspersed with forested islands on raised ground and graded Cerrado habitat at intermediate altitudes (Langstroth (in press); Mayle *et al.* 2007). Overall however, the plains are extremely flat with little variation in elevation - typically ranging from only 100 to 200m above mean sea level. Mean annual temperatures range from 21-27ºC and annual precipitation varies between 1100 – 2500mm, with the majority falling in a distinctly long wet season between September and May (Haase & Beck 1989). During this time, a substantial increase in discharge rate occurs in the Beni, Mamoré and Iternéz rivers, as well as other associated tributaries which traverse the Llanos (Hamilton *et al.* 2004) due to increased snowmelt in the upstream high Andes. 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). (See Figure 1.4)

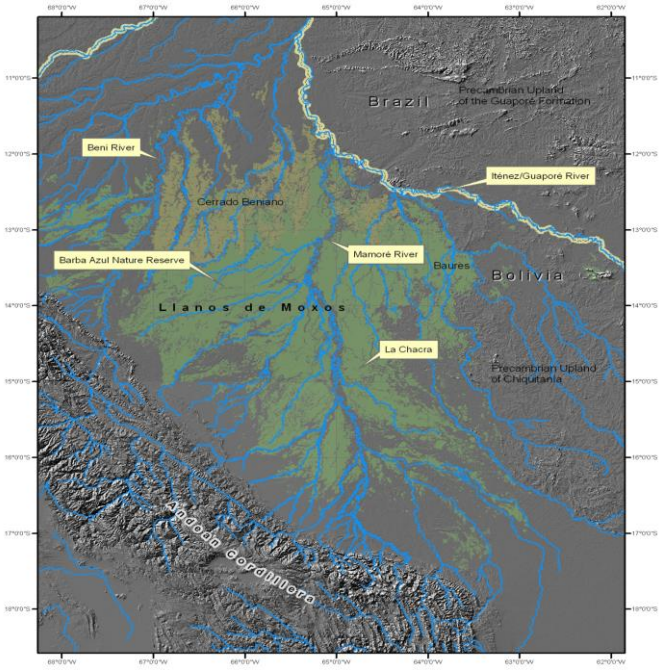

Figure 1.4: *Map of the Beni Department, showing the Llanos de Moxos Floodplains. Map also displays the relative positions of the three main river systems of the region, The Rivers: Ben; Mamoré and Itenez and the Reserva Barba Azul. From Langstroth (in press)*

The Reserva Barba Azul & Glasgow Expeditions:

In 2008, Bolivian Birdlife International partner, Association Armonia, facilitated the purchase of the 3558hectare Reserva Barba Azul (RBA) - now known as Reserva Barba Azul North (RBAN) - creating the very first protected area within the Beni savannah ecosystem. From the outset, Armonia aimed to promote 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 reserve manager to maintain and protect the reserves boundaries and to remove the herds that inevitably strayed in from time to time. This has been greatly successful and the reserves regeneration is very visibly underway.

In May 2010 the reserve was expanded by a further 1160hectares, following the purchase of Juvena ranch- now known as Reserva Barba Azul South (RBAS). The south of the reserve is starkly different to the north, still having a large active cattle presence. Currently, the savannahs in this section are short, heavily grazed and well trampled. It is thus considered likely that diversity is more limited here compared to RBAN. Cattle are due to be removed from RBAS this year and it is hoped that regeneration will be as successful as that of the RBA north.

The RBA was chiefly set up to protect one of the largest remaining wild populations of critically endangered blue-throated macaw (*Ara glaucogularis*), a species endemic to the Beni Savannas and for which the reserve is named (Barba Azul meaning “blue beard” in Spanish - their local colloquial name). The reserve was the first area ever to be to set aside for the protection this charismatic 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. A 2010 Glasgow University monitoring scheme found more that 100 blue throated macaws were regularly using the reserve. This is the largest population of these magnificent birds currently known and highlights the significance and vast importance of the reserve for their protection.

Since the initial purchase of RBA north, data collection on avifauna has ranked high in priority for Armonia. However studies of mammalian, herpetological, ichthyological and botanical elements of the reserve have also been integral to increasing biological understanding of the region. Many local scientists have been involved with producing comprehensive species lists of the reserves flora and fauna. Expedition teams from the University of Glasgow’s Exploration Society have also contributed greatly to knowledge of the reserves diversity since involvement with the project began in 2009. Our studies have moved fluidly from conducting simple, but integral, inventories of species diversity within the reserve, initially highlighting the presence of several vulnerable and near threatened species, through to setting up successful monitoring schemes and insightful behavioural and ecological studies to assist in their protection.

Armonia’s current aims for the reserve are: to maintain & improve protection of the reserve while continuing to monitor blue throated macaw populations; to promote biological research on other elements of the reserves flora & fauna with specific respect to vulnerable and threatened species; to expand the reserves area & 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.

Study Site

Reserve Overview: The RBA 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 (13º45'S, 66º07'W; Altitude 170m). The site consists of two sections: the RBA north - a 36km² (3558 hectare) section of the reserve formally managed as San Lorenzo Ranch sitting on the northern banks of the Rio Omi & RBA south a 12km² (1160 hectare) section of the reserve formally managed as Juvena Ranch sitting on the southern banks of the Rio Omi. There is no development within or around the reserve, with the exception of a few, small, neighbouring 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 impassable during the wet season. The reserves habitats constitute a savannah-mosaic which includes forested habitats and wetland/riparian zones. The layout of the reserve is indicated in figure 1.5.

Figure 1.5: *Satellite map of the Reserva Barba Azul. Reserve boundary shown in red Barba Azul Reserve = RBA north & Juvena = RBA south. (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 of the RBA north's' northern limits. Larger islands, possibly remnants of ancient gallery forest (Mayle *et al* 2006), are found forming a chain like archipelagos near the banks of the Rio Omi in both the RBA north and south. 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 RBA north.

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). 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, expedition botanist, personal comment).

Riparian and Wetland habitats: A small area of wetland habitat (WET) lies at the northern end of the RBA north, consisting of damp and dry grasslands interspersed with several small forested islands (See Figure 1.6). Riparian and wetland zones also occur alongside the river in the south of the RBA north. Water levels vary in each of these zones from year to year – probably depending on the level of wet season flooding and subsequent dry season temperatures.

Figure 1.6: *View over the wetland grasslands at the northern limit of the Reserva Barba Azul.*

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2. Expedition Financial Summary 2012

The projected cost of the expedition plus a 10% contingency was £17,675. Personal contributions were set at £ 800 per student, providing a total of £ 6,400 and £11,275 to be raised through fundraising.

Projected Costs (£)

Flights Glasgow-Santa Cruz	8800
Administration	250
Training Courses	300
Equipment	2200
Accommodation	1500
Transport	1000
Wages	900
Post Expedition	450
Reserve Fee	1600
Contingency (10%)	1767

Total - 17,675

Expedition Income (£)

Personal Contributions	6400
Grant: University of Glasgow	1400
Grant: Royal Geographical Society	750
Grant: Zoological Society of London	800
Grant: Carnegie Trust	2000

Grant: Glasgow Natural History Society	700
Grant: Albert Reckitt Charitable Trust	250
Grant: Gilchrist Educational Trust	1000
Grant: Chester Zoo Studentship	780
Fundraising Activities	2800
Total – 16,880	

Expedition Expenditure (£)

Flights	9000
Food	1500
Wages	900
Accommodation	350
Transport	1200
Medical kit and first aid course	300
Equipment (Camera Traps/protective clothing/books/stationary)	1500
Reserve Fee	1600
Post-Expedition Costs (report write up/printing/translation)	300
Total - £16,650	

After contingency we expected a budget shortfall, however, we ended up with a budget surplus which suggests our estimation of the budget based on previous expeditions to Bolivia was fairly accurate. The surplus money will be used to contribute towards the follow up expedition which is planned for summer 2014.

3. New Large Mammal Records & Updated Reserve Species List

Figure 2.1: *The pampas deer (Ozotoceros bezoarticus) – a species classified as near threatened on the IUCN redlist, which has been known to be using the reserve since 2009. (Photograph by Ryan Ward 2012)*

Written by Jo Kingsbury

Introduction:

The Beni Savannahs are home to a large diversity of mammals with one hundred and forty six species found to inhabit the region (Beck & Moraes 1997). The mammal assemblage found here is also very unique - many species are shared with the lowland tropical forests of the Amazon basin to the north while others are shared with the neighbouring Gran Chaco grasslands to the west. Past studies conducted by University of Glasgow expedition teams have identified The Reserva Barba Azul (RBA) as an important haven for this biodiversity. A number of key conservation species have been found to use the RBA including big cat species such as jaguar, puma and ocelot. Additionally, a number of globally threatened species including the vulnerable giant ant-eater, *Myrmecophaga tridactyla*, near threatened pampas deer, *Ozotoceros bezoarticus* (see figure 2.1), and Maned wolf*, Chrysocyon brachyurus* (see figure 2.2) have been frequently recorded by our annual surveys and photographed frequently by our digital camera trap networks since 2009.

Figure 2.2: *Maned wolf (Chrysocyon brachyurus) – a species known to be using the reserve since 2009 and photographed on camera trap networks annually since 2010*

More common elements of the mammalian fauna include abundant howler monkeys (*Alouatta caraya*), numerous capybara (*Hydrochoerus hydrochaeris*), southern tamandua (*Tamandua tetradactyla)* (See Figure 2.3), crab eating fox (*Cerdocyon thous)* and yellow armadillo *(Euphractus sexcinctus)* (see figure 2.4).

Figure 2.3: *Southern tamandua, (Tamandua tetradactyla) – a species commonly encountered on the reserve (photograph by Jo Kingsbury)*

Figure 2.4: yellow armadillo *(Euphractus sexcinctus). – a species commonly encountered on the reserve (photograph by Jo Kingsbury)*

New Records for 2012

A few notable records are worth mentioning here, in addition to the study outlined in the main mammal report. Two new and very important records of globally threatened species were achieved for the reserve this year. The first, a post-fire camera trap image of pampas cat, *leopardus colocol* (see figure 2.6) - a species considered near-threatened and whose populations are currently in decline across the South American continent due to habitat conversion for agriculture and stock grazing (Pereira et al 2008). Although the species characteristically inhabits scrub grasslands and swamp-wetland habitat like that typical of the RBA, the species does not yet appear to have been recorded this far north in Bolivia (see figure 2.7), such that this record may represent a range extension for the species.

Figure 2.6: *The near-threatened pampas cat (Leopardus colocol) – camera trap image of the species captured post-fire in RBAN.*

Figure 2.7: *Map of the extant distribution of the near-threatened pampas cat (Leopardus colocol) shown in yellow with the location of the RBA shown in red (image from adapted from Pereira et al 2008).*

We also encountered and photographed marsh deer, *Blastocerus dichotomus*, on the reserve for the first time (see figure 2.8) - a species categorised as Vulnerable on the IUCN redlist and listed on CITES Appendix 1 (Duarte et al 2008). A single marsh deer observation had been recorded by Glasgow University expedition teams during the 2011 field season. However, on that occasion identification was not confirmed as the sighting was brief and photographic evidence not obtained. Marsh deer have experienced serious population declines and are considered regionally extinct across much of their former range (see figure 2.9). This is thought to stem from multiple factors including habitat loss, land conversion for agriculture, hunting, transmission of cattle diseases and anthropogenic alterations to natural hydrological regimes via processes such as wetland drainage and damming. Current populations are highly fragmented with Brazil's Pentenal region considered the last major stronghold for the species. (Duarte et al 2008) However, a recent aerial study also highlighted the importance of the Beni savannahs with population densities estimated between 0.12 - 0.24km^{-2} across a 27 680km^2 study area (Rios-Uzeda & Mourao 2010). The protection offered by the RBA and the undisturbed habitat it provides offers a valuable haven for marsh deer populations in the region.

Figure 2.9: *The vulnerable marsh deer (Blastocerus dichotomus) – image of the species captured pre-fire in flooded grasslands at the far northern limit of RBAN. (Photographed by Jo Kingsbury)*

Figure 2.10: *Map showing the extant range of the near-threatened mash deer (Blastocerus dichotomus) in yellow with respect to its former distribution in red. The location of the RBA is indicated in blue (image adapted from Duarte et al 2008).*

An additional new record was also achieved during one of our night transects when a large troop of Azara's night monkey's *(Subspecies - Aotus azarae boliviensis) were encountered. Although this species is not considered globally threatened, its population is thought to be in decline with threats including deforestation and land conversion for agriculture. (*Fernandez-Duque et al 2008) *Expedition teams had suspected the presence of night monkeys on the reserve in the past since local guides and farmers had informed us of encounters with them. The nocturnal nature of the species means they are often missed from surveys or understudied so we were glad to have finally crossed paths.*

Following these records, the species list of large mammal for the reserve now sits at 24 these species, the method the record was achieved and the species IUCN category are as follows:

SPECIES	OBSERVATION TYPE (T=track/S=scat/C=camera trap/V=visual Encounter/A =aural/O=other)	IUCN STATUS (VUL=vulnerable/NT = near-threatened/LC= least concern)
Jaguar (*Panthera onca)* -	T	**NT**
Puma *(Puma concolor)* -	T/S/C/V/O – kills observed	**LC**
Ocelot *(Leopardus pardalis)* -	T/C/V/O – Kills observed	**LC**
Jaguarundi (*Puma yagouaroundi)*	V/T	**LC**
Pampas cat *(Leopardus colocolo)*	C	**NT**
Marsh deer *(Blastocerus dichotomus)*	V	**VUL**
Pampas deer *(Ozotoceros bezoarticus)*	V/T/C/S	**NT**
Gray brocket deer *(Mazama gouazoubira)*	V	**LC**
Maned wolf *(Chrysocyon brachyurus)*	T/S/C/	**NT**
Crab eating fox *(Cerdocyon thous*)	T/S/C/V	**LC**
Giant anteater *(Myrmecophaga tridactyla*)	T/C/V	**VUL**
Southern tamandua *(Tamandua tetradactyla)*	T/C/V	**LC**
Collared peccary *(Pecari tajacu)*	T/S/C/V	**LC**
Capybara (Hydrochoerus hydrochaeris)	T/S/C/V	**LC**
Black howler monkey (Alouatta caraya)	S/C/V	**LC**
Azara's night monkey *(Aotus azarae boliviensis)*	*A*	**LC**
Crab-eating racoon (Procyon cancrivorus)	T/C/V	**LC**
South American coati (Nasua nasua)	C/V	**LC**
Black-eared opossum (Didelphis marsupialis)	C/V	**LC**
Brown agouti (Dasyprocta variegate)	C/V	**LC**
Spotted Paca (Cuniculus paca)	*C/V*	**LC**
Yellow armadillo (Euphractus sexcinctus)	*C/V/T*	**LC**
Nine-banded armadillo (Dasypus novemcinctus)	*C/V/T*	**LC**
Brazilian Porcupine *(Coendou prehensilis)*	V/O (Spines found)	**LC**

All species on this up-to-date species list for the reserve were encountered on the 2012 expedition with the exception of jaguarundi.

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4.Mammal Report:

Assessing Diversity, Abundance and Conservational Importance of Large Mammal Species Experiencing Man-made Disturbances (Fire and Cattle Grazing) in a Neo-tropical Savannah Ecosystem

Written by Ryan Ward

Abstract

The main objectives of this study are to understand the fundamental differences and changes in abundance and diversity of large mammals in relation to two disturbances in the Beni savannah ecosystem within the Barba Azul reserve, northern Bolivia. Disturbances studied were the presence of cattle grazing compared to an area which is not grazed by cattle, and the disturbance caused by a man-made fire in comparison to the same area pre-fire. The data for this project was gathered by completing night and day transects, scat and track transects, using camera traps and random encounters. This project will concentrate mainly on the four habitat types present: cerrado, forest, river and savannah grassland. Each habitat and method was chosen to increase the chance of encountering mammalian species in their natural habitats. Cattle disturbance showed no significance (Transects; (R-Sq=72.41%, P-Value=0.204. Camera Traps; R-Sq=69.74%, P-Value=0.713. Random encounters; P=0.056). Fire disturbance however showed very significant differences (transect data; R-Sq=99.4%, P-Value= 0.0001. camera traps; R-Sq= 97.19%, P-Value= 0.001). The results show that fire does cause very significant changes to the diversity and abundance of the species within the disturbance area. Although cattle disturbance shows little significance, it is well documented that prolonged cattle grazing has severe implications upon ecosystems. Therefore, the lack of significance could be attributed to data collection time being limited by the occurrence of fire.

Introduction

In 2008 the Association Armonia purchased 3558 hectares of land to protect one of the largest remaining populations of the Blue-throated Macaw (see *Ref. Pic. 1*) aptly named Reserva Barba Azul (RBA) , which translates as “Bluebeard”, (formally a fully operational cattle ranch) after the charismatic birds. This area is known colloquially as San Lorenzo. Buying this land gave way to numerous conservation opportunities involving threatened mammal and raptor species of the savannah. One of the main objectives Armonia began was to remove cattle from the ranch land, prevent entry of cattle from neighbouring ranches (erecting fences) and appointing a park ranger to monitor the reserve. They allowed the habitats to recover from the damage the cattle grazing caused, as well as stopping manmade fires and restoring the reserve back to a more natural state. This has been a large success as from my observations Pampas Deer were found in higher densities here than in Juvenna; an area where cattle are still present in high numbers (See Results section). The discovery of the Pampas Cat (*Leopardus pajeros*) has allowed for the purchase of a neighbouring ranch (the Pelotal ranch) which will increase the size of the reserve to 20,552 acres. Armonia is a non-profit organisation which focuses on many projects dealing with a variety of subjects. The main focus point of conservation within RBA is that of the Blue-thoated Macaw, endemic to the Beni ecosystem. The RBA contains one of the largest populations of the Blue-throated Macaw with around 50-60 individuals (around 350 remaining in the world) meaning this reserve is of extreme importance. This study is interesting as it allows for a detailed picture of the reserve and its species. It allows for more research to be undertaken in the reserve and with the new ranch being bought over in the future increased conservational effort can be implemented in protecting this unique ecosystem.

Reference Picture 1: This represents the endemic Blue-throated Macaw taken within the Barba Azul Reserve.

The Barba Azul reserve lies within The Beni savannah (locally known as the Llanos de Moxos) located in the west Mamoré river region approximately 75km west of Santa Ana de Yacuma, Bolivia. Every year 50-60% of the Beni floods, with waters reaching their highest levels from May to April and lowest in October (Hamilton K.S *et al,* 2004). Due to high volumes of rainfall and snowmelt from the Andes, which allows for permanent swamp and marsh to dominate much of the land throughout the year. The average temperature is 25^{o}C with numbers frequently reaching 35-37^{o}C daily. The Beni covers an area of around 150,000km^2 with floral diversity varying between areas of temporal inundation (savannah grassland) and evergreen forests which lie on higher areas of land. Flooding is a very important ecological factor in the maintenance of the savannah grassland vegetation as it restores essential nutrients and minerals back to the soil and is key to maintaining different ecological niches dependant on water levels in a given area (Hamilton K.S *et al,* 2004). Natural fire is another common disturbance factor important in keeping the ecological health of the habitats high. The occurrence of fires is natural in these environments (caused by lightning strikes for example) however, man-made fires lit by ranchers will burn thousands of acres in an unsustainable manner to allow regeneration of new grass for their cattle to graze upon (Mayle F.E. *et al,* 1987). These are the main threats to the Beni ecoregion (WWF, 2012); fire and overgrazing.

Grazing pressure changes the floral mosaic, opening up niches for less dominant species thus creating higher species richness which in unnatural to the area and the species within it. Trampling also reduces the soil bulk density meaning there is less air space within the soil which reduces the water holding capacity thus increasing the height of flooding. This has an effect on the height of the grass, creating problems for species such as Pampas Deer and Maned Wolf who use the grass as cover for escaping predators or for predating on other animals (Altesor, A. *Et al,* 2006) as well as the destruction of niches usually occupied by smaller mammals such as mice.

The reserve habitats comprise of 4 main types (within a savannah-mosaic) including forest (forest islands), intermediate succession zones, grassland and wetland/ riparian zones (Kingsbury. J, 2010). The plant diversity is extremely large with 1,500 species living within the savannah habitat, with more

in the forest environments (2,000 species). The area surrounding the reserve and the reserve itself is development free apart from the buildings used by estancia owners and small dirt roads connecting them, the only access is during the dry season and by 4x4 vehicles only. Within Juvenna (Still managed as a ranch) there is also a small landing strip accessible only to small lightweight aircraft (Kingsbury. J, 2010).

On both sides (San Lorenzo and Juvenna) the savannah habitat dominates over the others. Species diversity is low within the Savannah areas; compromising of rolling dense grassland difficult to traverse by large mammals. The only paths present through this area are man-made; these were used as transects as they were the most likely area to see mammals which seemed to use the paths as linking corridors between forest and other habitats. Cerrado is characterised by small shrubs, trees and shorter patches of grass, they are transitional areas found at the edges of the savannah and just before the forest islands often joining forest islands. The Cerrado is somewhat similar to savannah diversity and abundance levels however, there is a higher chance that a mammal will use the paths between the forest islands and therefore more sightings may be made here. The forest habitats are found in patches or 'islands' which can vary in size dramatically from 10m in diameter to 100m, with very long lines (at least 5km) of forest following the river almost perfectly. There are varying hypothesis of how the forest islands formed; some archaeological evidence indicates evidence of early Paelo-Indians moving the soils and ground to fit their needs, however there are also large termite mounds which can allow trees to colonize (Mayles F.E. *Et al,* 1987). These areas contain dense woodland towards the outer edges bordering with cerrado making way to a more open distribution of trees towards the centre. The forest appeared to hold the highest abundance of mammal life with proportionally higher mammal diversity recorded here than the other habitats. The river habitat is very marshy and susceptible to flooding each year during the wet season. This habitat has a diverse array of bird, reptile and mammal species (mainly Capybara). Riverside land is characteristically flat with short grass, which is not difficult to walk.

The neo-tropics of South America are of great importance and interest as it is one of the world's greatest biodiversity hotspots. Species diversity in these area of South America is quite large; ten thousand plant species, one-hundred and sixty-one mammal species, eight-hundred and eighty seven bird species, one-hundred and fifty amphibian and one-hundred and twenty reptile species have been observed and recorded within the 1.86 million Km^2 area of South America. Due to this high diversity there are many areas of study available to gain a higher understanding of the habitats and for an insight into how important tropical savannahs are (Maria Cardoso. D. S. J. & Bates. J. M. 2002). However it appears that there is more conservation of savannahs in Africa rather than in South America. This may be due to the mass of tourists that seek an adventure on safari to see Lions in their natural habitat out in the open, watching Elephants and other large, charismatic mammals found here. Africa is also home to the worlds most diverse and largest populations of ungulates (J.T. Du Toit and D.H.M. Cumming, 1999) which attracts many scientists and tourists alike. Africa overall has a higher species richness above the weight category of 5kg; South America is only more rich below the weight category of 5kg (Vivi D.M. & Camingnotto A.P, 2004). The fact that the number of species is higher in Africa than in South American may still attract more travellers and academics. Savannah is only now getting the recognition that tropical rainforests have now because of the importance in biodiversity which it contains (Maria Cardoso. D. S. J. & Bates. J. M. 2002). Another point of interest is that unlike African Savannahs, South American Grasslands have no endemic (large) herd grazing species therefore the addition of them would theoretically create disturbance.

This study is to involve the research of mammal diversity and abundances in both disturbed and undisturbed habitats over two locations. The main habitats studied are cerrado, forest, river and savannah. The two locations studied are San Lorenzo (Cattle free) and Juvenna (grazed by cattle) which each contain all of the above habitats respectively. However, an area was studied within San Lorenzo towards the back of the reserve on the north side; this contained small forest islands as well as

savannah. This was done in the interest of seeing if there is any marked difference between the diversity and abundance of mammals at the back in comparison to the similar (slightly more disturbed) habitats closer to camp.

Important species such as the Maned Wolf, Ocelot, Puma, Giant Anteater, Pampas Cat, Pampas Deer and on rare occasions Jaguar are found within the reserve creating opportunities for conservation projects. Jaguar has not been observed by any team member since the beginning of the expeditions in 2009, however one sighting has been reported next to San Lorenzo by a neighbouring rancher. It is rare for Jaguar to remain within the reserve as individuals are more likely to pass though. Jaguar prints found show evidence (seen in the results section) of an individual(s) going to and leaving from the River at San Lorenzo.

Jaguars (*Panthera onca)* are the third largest species of Cat in the world next to Tigers and Lions, and are the largest Cat in the western hemisphere. Average territory size of an individual is around 25-50km^2 and can be found in a large range of habitats; preferring dense forested areas with enough cover to hide whilst hunting. Jaguars exhibit crepuscular activity and predate upon a variety of animals (Nogueira, J. 2009). Jaguar populations range throughout the Americas (however they have been limited to only 3 states in the USA: Arizona, Texas and New Mexico since the 1940s (Dagggett P.M. & Henning D.R. 1974)) from South Arizona and New Mexico south to Northern Argentina and North Eastern Brazil (Nogueira, J. 2009). Jaguars are currently near threatened according to the IUCN due to destruction of habitat and persecution by humans (Valderrama, C. 2008).

Reference Picture 2: This is a camera trap picture from the cerrado path in San Lorenzo of a Maned Wolf (no tail).

The Maned Wolf (*Chrusocyon brachyurus*) (See *Ref. Pic* 2) is endemic to South America and is their largest canine species standing at almost 1m tall at the shoulder. The geographical range of this canine was once larger than present, the reduction in range most likely due to the increase in cattle ranches, agriculture (conversion of the wetlands and savannah into crop land) and hunting for indiscriminate reasons (Gorog, A. 1999; Queirdo D. *et al* 2011). The current distribution is within central Brazil, Paraguay and the lowlands of Bolivia with lower densities found in north and northeast Argentina, Uruguay and the extreme south of Brazil (Queirdo D. *et al* 2011). It is almost only found in cerrado, Chaco and pampas regions (areas of grassland) as it uses the long grass and shrubbery for cover and hunting. The Maned Wolf has an omnivorous diet with rodents, rabbits, armadillos, fish, birds and bird's eggs, reptiles, gastropods, insects and ripe fruit within season and some vegetation (Gorog, A. 1999). According to the IUCN the Maned Wolf is near threatened with the most serious threats being the destruction of habitat for agriculture and cattle ranching (Rodden, M. *Et al,* 2008).

Reference Picture 3: This is a camera trap picture from the cerrado path in Juvenna of an Ocelot.

Ocelot (*Leopardus pardalis)* (See *Ref. Pic. 3*), is a small cat species found throughout the Americas ranging from Central America and all countries between south eastern US (Texas, Arizona) and Northern Argentina. Like most cat species Ocelot are Nocturnal (and crepuscular) and are active for 12 hours a day. Their territory range is 2-31Km^2, habitat depending. Prey species include small mammals (such as nocturnal rodents including common Agoutis (*Dasyprocta)* and Cane Mice (*Zygodontomys*). Ocelot will also take larger prey such as Spider monkeys (*Saimiri sciureus*) and the Lesser Anteater (*Tamandua tetradactyla*). The Ocelot`s conservational status is least concern according to the IUCN, however, threats to this species are habitat destruction and illegal hunting and selling of pelts (Kittel, J. 2011; Valderrama, C. 2008).

Reference Picture 4: This Picture if of a Puma, taken on a camera trap in the Cerrado.

Puma (*Puma concolor)*(See *Ref. Pic. 4*), considered a small cat due to its inability to roar as large cats do (Lions and Tigers) however it has a body size of 29—120kg (Shivaraju, A. 2003). Puma have the widest geographical range of any mammal in the western hemisphere (Shivaraju, A. 2003) stretching from Northern America to the Southern tip of Argentina and Chile as well as Southern Alaska (The Encyclopaedia of Mammals, 2009). This can be attributed to the Puma's ability to adapt to the multitude of habitats present within the Americas including; coniferous and tropical forests, grasslands, swamps, dry brush country, and any other habitat where there is sufficient cover and abundant prey (Shivaraju, A. 2003). Their habitat size can vary quite dramatically depending on the abundance of prey in the area. Habitat sizes also varies between the sexes also differ just as dramatically with female habitats ranging from 26-350km^2 and males ranging from 140-760km^2 (Shivaraju, A. 2003), either way making their home range much larger than Jaguar. The territory of a male will never overlap with other males, but females will overlap quite substantially. Males will avoid one another and define territory boundaries through communications with scat, urine and tree scrapes (Shivaraju, A. 2003). Individuals are largely solitary and like most cat species will only come together during mating periods. They are an ambush predator that feed on varied prey depending on habitat, taking mammals as large as deer as well as smaller species such as Armadillos, Racoons and feral pigs (Valderrama, C. & & Lucherini, M. 2008). Puma are considered to be of least concern in terms of their conservational status (Valderrama, C. & & Lucherini, M. 2008) although, are under threat through habitat loss and fragmentation as well as human persecution due to some puma related deaths in Northern America (Valderrama, C. & & Lucherini, M. 2008). This behaviour has been occurring for hundreds of years as During the colonisation of Northern America Puma were hunted to extinction in eastern North America (Valderrama, C. & & Lucherini, M. 2008).

Reference Picture 5: This is a Giant Anteater with a juvenile on her back. This was taken on a camera trap in the river in San Lorenzo.

The Giant Anteater (*Myrmecophaga tridactyla*) (See *Ref. Pic. 5*) is the largest of the four anteater species; Northern Tamandua, Southern Tamandua and the Silky Tamandua. Males weigh between 26-36Kg and females weigh between 26-31Kg (Shaw J. H. 1987) are able to grow up to 2m in length from snout to tail (Woltanski, A. 2004). Giant Anteater range from Central to South America (Southern Belize and Guatemala to Northern Argentina) (Woltanski, A. 2004). Giant Anteater inhabit a wide range of habitats; forest, swamp and grassland (Woltanski, A. 2004) however, when sleeping individuals build nests in grassland areas whereas feeding occurs more often within forests (Shaw J. H. 1987). They are usually solitary animals except females and their young and during the mating ritual where the male may not leave the females side for days feeding with her at the same ant/termite nest (Shaw J. H. 1987). They predominately feed on ants, termites and small grubs with the occasional opportunistic piece of fruit. Using their incredibly strong, perfectly adapted sharp claws on the front paws the Giant Anteater will tear open a nest and consume thousands of ants/termites a day (Woltanski, A. 2004). Due to its large size only the biggest of predators can bring one down, such as Puma and Jaguar. The Giant Anteater is considered to be vulnerable in terms of their conservational status (The IUCN Red List of Threatened Species, *Mymecophaga tridactyla* (Giant Anteater) 2012). The threats that this species faces are similar to many endangered animals now; habitat reduction and human persecution as a pest (Miranda, F. & Medri, I. 2010).

Reference Picture 6: This is a camera trap picture taken in the savannah of a Pampas Cat passing by.

The Pampas Cat (*Leopardus colocolo*) (See *Ref. Pic 6*) is a small feline that largely resembles a large domestic cat, weighing only 3-7Kg (Golden, R. 2003). The geographical range of this small cat is very varied ranging from most of Argentina and southern Uruguay, Bolivia, Paraguay, Brazil (within the dry forests) and north through the Andes mountain chain in Ecuador and possible habitation in south eastern Columbia (Pereira, J. *Et al* 2008). The Pampas Cat has adapted to dwell within more habitats than any other small cat in South America (Arkive, Pampas Cat (*Leopardo colocolo*), 2012) being able to live in open woodland or shrub thicket, cloud forest, cold, semi arid desert regions, low lying swamps, flood plains and mountainous areas (Golden, R. 2003). There are 3 morphs, within the 3 main geographical habitats of the cat that are so pronounced, genetic studies are currently taking place to establish whether the Pampas Cat is one species or three (Golden, R. 2003; Arkive, Pampas Cat (*Leopardo colocolo*) 2012). Due to this cat being very small and secretive the behaviour is much understudied and not much is known unless it is in captivity except that it is most likely nocturnal and predominantly terrestrial (Golden, R. 2003). It feeds upon small mammal species such as Guinea Pigs and ground dwelling birds. It has also been noted that it will take poultry from human settlements and penguin eggs in Argentina (Golden, R. 2003). According to the IUCN Red List of Threatened Species the Pampas Cat is near threatened. The main threats reducing their numbers are habitat loss and degradation due to cattle and human settlements, human persecution, road traffic accidents and traditional hunting (Pereira, J. *Et al* 2008).

Reference Picture 7: This picture was taken in the Savannah in San Lorenzo. In the background the savannah grassland is at ground level due to the fire which occurred.

Pampas Deer (*Ozotoceros bezoarticus)* (See *Ref. Pic. 7*) are a medium sized deer weighing around 30-40Kg (D'Elia, G. 1999) and are found throughout South America. They have quite a large geographical range covering Brazil, Argentina, Paraguay and Bolivia (The Encyclopaedia of Mammals, 2009). However, populations used to range over a much larger area throughout South America (Eastern South America from 5º to 41ºS in the 1800s) but now only 1% percent of the habitat available in 1900 remains today Gonzalez, S. & Merino, M.L. 2008). Their habitat consists of very large open areas of grassland and cerrado where they were observed as well as feeding on shorter, more succulent grass near the river (Self Observations). During the time at the reserve Pampas Deer were only spotted in the savannah beside the river, the grass is tall enough for the deer to flee and hide, which they did on many occasions once spotted. After the fire the number of observations increased due to new grass growing and the deer taking full advantage (Self Observations). They are found in small groups however, it is more common to see a solitary deer (D'Elia, G. 1999). There are no barriers between individuals and groups, and it is common for individuals, mostly males, to join a different group (D'Elia, G. 1999). From my own observations, once sighted the animals may make whistling noises from their nostrils, hoof stamping, raising of the tail, freezing, staring and fleeing. Pampas Deer are near threatened according to the IUCN red list of threatened species due to many factors (Gonzalez, S. & Merino, M.L. 2008). The main threats to the Pampas Deer is habitat destruction from human settlements, agriculture and habitat degradation from cattle ranching and other livestock farming (Gonzalez, S. & Merino, M.L. 2008). Other threats include over-exploitation for their meat, fur, antlers and for recreational hunting purposes (Gonzalez, S. & Merino, M.L. 2008).

The two comparison areas looked at: San Lorenzo and Juvenna, hold the same habitat types however, the main difference is that Juvenna contains many cattle which harm the natural environment through intense grazing and trampling disturbance. This disturbance and damage of the natural succession of savannah grassland habitat may have had a negative influence on the diversity of mammals within each habitat in the Juvenna area. San Lorenzo no longer contains any cattle and is therefore a much

healthier and natural environment thus allowing the assumption that mammal abundance will be greater in this area.

Transects were undertaken on both sides to understand whether or not cattle are a key influence on the abundance and/or diversity of mammalian life. The abundance and diversity of mammal species was measured by using a number of camera traps strategically placed throughout the reserve and within each habitat using signs such as mammal-made pathways, scat or simple tracks and random observations along known transect lines.

During the time spent at the reserve a fire was created by a neighbouring ranch to create pasture land for cattle. This fire spread onto the reserve on the San Lorenzo side and by the thirteenth of August the fire had destroyed the entire savannah habitat as well as some areas of cerrado (See title image). During this time Juvenna was removed as a study area and the main focus was made on San Lorenzo. Due to the change in situation new hypothesis were made relating the occurrence of fire to mammal diversity patterns/ abundance changes. Methods were also altered to take advantage of the opportunity.

Aims

The aims of this project is to understand whether there will be any differences between land uses, one area of which still contains cattle and compare this to an area with no cattle and thus understand if this has any effect on the mammalian abundance and diversity levels relating to any possible effects caused by agriculture. The last aim of this project is to look at fire and potential disturbance it may cause to the species and the abundance of the mammals within San Lorenzo. This is to be compared with any effect within Juvenna to understand whether, if there is a change, the fire was actually the cause of it. Within San Lorezno pre-fire data will be compared to post-fire data.

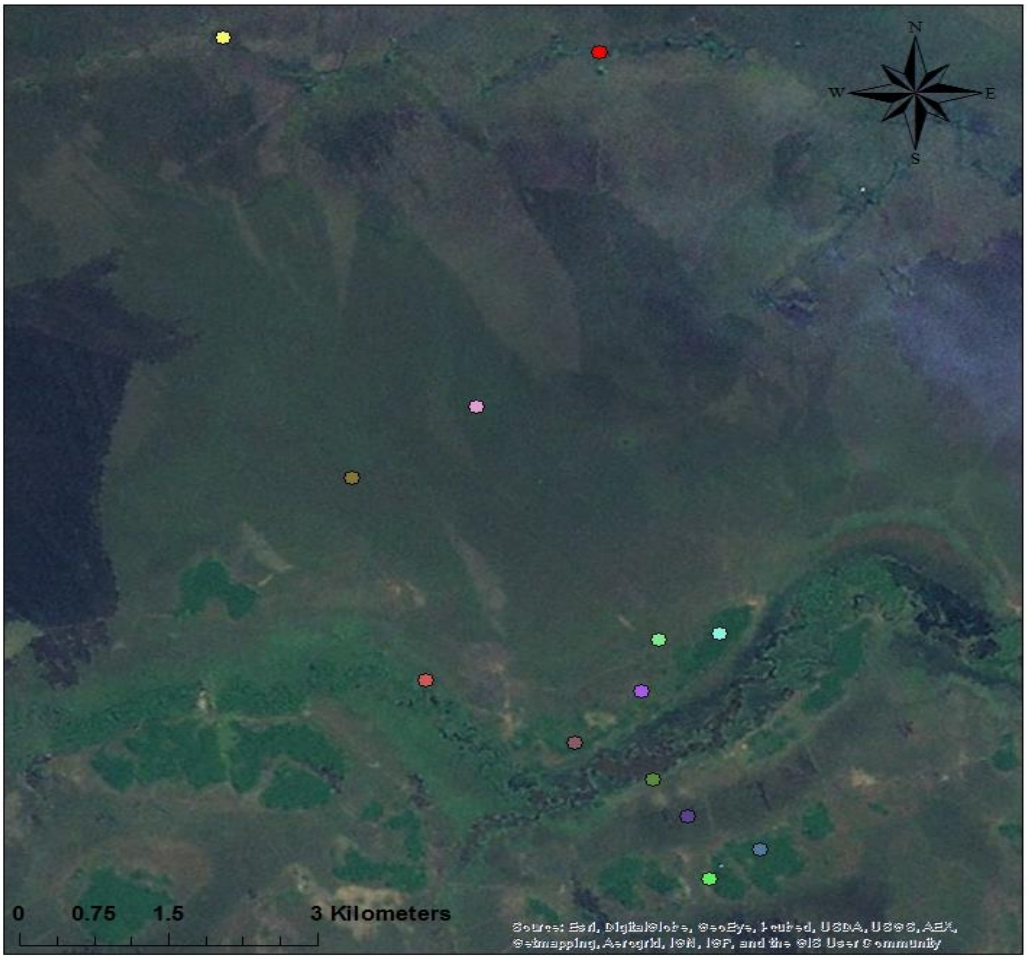
My hypothesis for this project is that there will be a difference in the species diversity and abundance between areas with cattle (Juvenna) than an area without cattle (San Lorenzo). The fire will cause differences in the diversity and abundances of species within the San Lorenzo area Post-fire.

Methods

Camera Traps:

During the study thirteen sets of camera traps will be used with each set containing two cameras (See *Map 3*). The camera models used are Cuddeback Capture IR, Bushnell Trophy Cam 2011 Trail Camera and Bushnell Trophy Cam 2012 Camera (HD). Eight sets will contain one Cuddeback and one Bushnell video camera, and the remaining five sets will contain two Cuddeback camera traps. There are a total of twenty-six cameras being used during this study, the majority of them being Cuddebacks (eighteen) (Bushnell: eight) which will be placed around the reserve in locations deemed to be mammal hot spots. Each Location will be scouted for any “obvious” pathways created by mammals and anything that can be attributed to mammal presence (scat, prints etc). Each pathway found will be made more obvious using tree branches, leaves and any other debris in an attempt to force any animal to use the path more often and in the direction of the cameras. Cameras will be placed in between two trees (around 2m apart) to securely hold them in place or, if this is not possible, using a posthole digger to dig a deep hole (around one foot) will be made to place a wooden post or large branch to attach the camera.

When attaching the camera to the post or tree, it is placed at a height of 40-50cm (Negreõs *et al,* 2010) and pointed away from the opposite camera to prevent the flash setting off adjacent traps. Before any camera trap is set batteries should be checked, memory cards wiped and checked, the date and time and the picture settings will be updated. The settings on the camera traps were as follows: the Cuddeback cameras were set to take a picture after a thirty second interval (after a picture has been taken), five megapixels, the size of the image 640x340 and the date and time will be set to when they are set. The Bushnell cameras will be set to take thirty second long videos with a twenty second interval, eight megapixels and the size of the image is 640x340. Each camera trap set is checked after 2-3 weeks to ensure that batteries have not diminished and/or if memory cards have not reached capacity, if so they are replaced. Upon completion of setting the camera a test will be carried out to ensure that the traps work. To test the cameras either a colleague or I shall crawl at a height similar to that of an average mammal and allow a picture to be taken. Once checked the camera is left for a total of 5-6 weeks, however each set may be in action for different periods of time. While placing the traps the GPS location, date and time will be noted in order to work out the encounter rates.



Map 3: This map shows the areas in which the camera traps were placed. Each of them marked with a coloured dot and each dot containing two camera traps (one camera trap set equals two cameras).

Camera Trap: Encounter Rate

The encounter rate was calculated by dividing the number of captures by the number of days the camera traps were out (this equals captures per camera trap day) and then this number was multiplied by one-hundred to give the number of captures per one-hundred days. Each encounter rate differed per area and also differed depending on what was being compared in the results. For example, with overall abundances each capture was divided by the total number of days of all camera traps and multiplied by one-hundred. This gives the encounter rate per camera trap day per one hundred days. Another example is when looking at separate habitats where the same formula is applied but a capture

from the forest on San Lorenzo would only be divided by the number camera trap days in the forest (the same applies to cerrado, savannah and river and on Juvenna). The final example is during the post and pre-fire comparisons between San Lorenzo and Juvenna where the total number of camera trap days for pre-fire and post-fire were used for each division.

Four habitats will be studied in the reserve: Forest Island, River Edge, Cerrado and Savannah (see *map 3*). The traps are spread out over these habitats in two locations: San Lorenzo and Juvenna. San Lorenzo will contain nine sets and Juvenna will contain four sets. More sets are placed in San Lorenzo due to its large size in comparison to Juvenna.

Once the study is over, the pictures are stored onto a computer and loaded onto Picasa. In Picasa each camera trap is to have a separate folder and each picture is to be tagged with information within the shot. This allows you to look at a certain species or a certain individual and makes it easier to identify an individual. Identification of an individual is depending on which species it is. With deer the size of antlers can be looked at to identify individuals, with Giant Anteater patterns on their fur can be compared to others and Ocelot`s spot patterns on their fur. This is more difficult with Crab-eating Fox and Agouti as there may be very little to differentiate between individuals.

Night Transects

Night transects will be conducted in five habitats in San Lorenzo and four habitats on Juvenna. Both sides contain one Forest, one Cerrado, one Savannah and one River Edge transect (See *Map 4*). San Lorenzo contains an extra transect that is located at the Back of the reserve where it can only be completed on horseback. The Back transect goes through mostly Savannah, however the transect circles around two very small forest islands. Each transect must begin at 21:00, should last minimum two hours at a slow walking pace to ensure stealth and talking is strictly prohibited (unless an animal is seen, and if that occurs only a small whisper is allowed). The maximum number of people on one transect is three with a minimum of two, which is most preferred. Each transect member must have a strong LED Lenser or a MAG Torchlight in order to see the surroundings and spot any animal and a machete

for protection. A GPS, pen, paper and a watch is necessary to note down the location (San Lorenzo or Juvenna), species, the number of individuals, sex (where possible), number of juveniles (if any), the number of adults (if possible), date, time of observation, start/end time of transect, habitat, GPS start/end of transect, moon phase (full, half full, quarter etc) (*Table 1*). When possible a picture of the animal should be taken for further reference. After the twelfth of August Juvenna is cut out to study further the San Lorenzo side to ensure the burnt areas are fully studied.

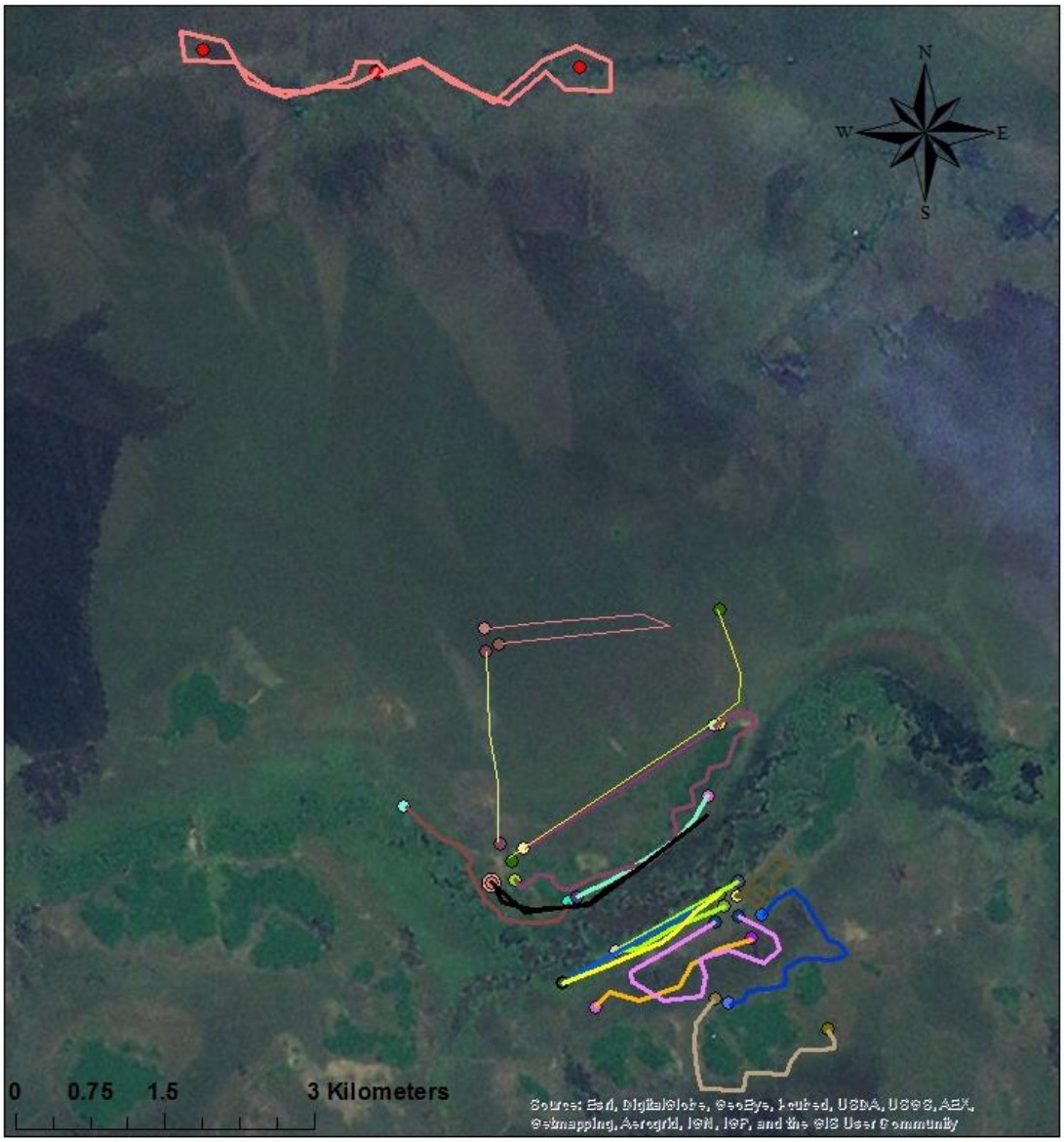
Habitat	**Location**	**Date**	**Time Start**	**Time End**	**GPS Start**	**GPS End**	**Moon Phase**
Species	**No. of Indv.**	**Sex**	**Adult**	**Juvenile**	**Time Spot**	**GPS**	**Description of Encounter**

Table 1: An example of the data collection technique for night transects, day transects and for random encounters where necessary.

Day Transects

These transects are included to allow a full search for any possibly mammal life both day and night. These transects were also involved in a raptor study which was conducted by Andrew McCondichie.

Whilst Andrew and another member of the team are searching for raptors they will be on lookout for mammals. Any mammals spotted must be noted down in the same manner as night transects and random encounters (*Table 2*). Each transect is 2km long with five points spaced about 500m apart. At each point a search was conducted for twenty minutes for raptors and mammals. The method in writing up a mammal observation is the same as in night transects (*table 1*). Transects are to be conducted in the four main habitats of the reserve, Cerrado, forest, river and savannah (See *Map 4*). Three conditions were studied, undisturbed land, burnt land and non burnt land. Each transect is repeated over the six week period.



Transect Lines, Start and End.

Habitat, TOD, Location		
Back, N, SL	Forest, D, J	River, N, J
Cerrado, D, J	Forest, D, SL	River, N, SL
Cerrado, D, SL	Forest, N, J	Savannah, D, J
Cerrado, N, J	Forest, N, SL	Savannah, D, SL
Cerrado, N, SL	River, D, J	Savannah, N, J
	River, D, SL	Savannah, N, SL

Map 4: This map represents each transect that took place in San Lorenzo and in Juvenna. This map also includes transects for scat and tracks with the back of the reserve the only exception.

Random Encounters

If an animal is encountered outside of a designated transect the GPS location, habitat, the time, species, number of individuals, number of adults, juveniles, notes on the behaviour and a description of the encounter should be documented. Documentation of a sighting is to be recorded the same as in the night transects (*Table 1*).

Mean Abundances

The mean abundance of each sighting is calculated for night/day transects, camera trap data and random encounter data. The mean abundance = the percentage abundance per sample. This is the division of one data point in the sample divided by the total number of individuals in the sample (the total number of individuals encountered pre or post-fire, or total number of individuals in San Lorenzo or Juvenna) and multiplied by one-hundred to give the percentage mean abundance for that sample (Wright, D.H. 1991).

Scat and Track Transects

Habitat		Location	Date	Start Time	End Time	GPS Start	GPS End				
Spp.	GPS	Total length	Total Breadth	Toe Length	Toe Breadth	Pad Length	Pad Breadth	Acetate	Ref. No.	Pic. No.	Notes

Table 2: An example of the data collection technique for scat and track transects.

This transect involves walking along a path for at least 1.5 hours looking to the ground to spot potential mammal tracks or scats. Once a track is spotted it is drawn onto an acetate with contains the date, habitat, location, a letter (A, B etc) to show which acetate of the track and a reference number (001, 002 etc) to show which track the data applies to. Each track should be measured, using callipers, in six ways: Total length and breadth of paw/hoof, length and breadth of Toe and the total length and breadth of Pad (if non-ungulate, measurement of toe and total breadth is satisfactory). If a scat is discovered the measurements which apply to it are the total length and breadth. Once all of the measurements are completed a picture is to be taken to give further reference. The data collection involves documenting the habitat, location, date, time start/end, GPS start/end, species (if known), abundance, measurements of track/scat, GPS location of track/scat, the reference number and the acetate reference (*Table 2*).

Scat and track transects will be conducted over four habitats (See *Map 4*) (forest, cerrado, savannah and river edge) over two locations (San Lorenzo and Juvenna) with each habitat containing two or more transects. There will be eight transects a week, with four on either side. One transect will only be completed once every two weeks to allow a recovery period.

Statistics:

Minitab is to be used for the statistical analysis using both paired T-tests and General Linear Models (GLMs) where necessary.

Mapping:

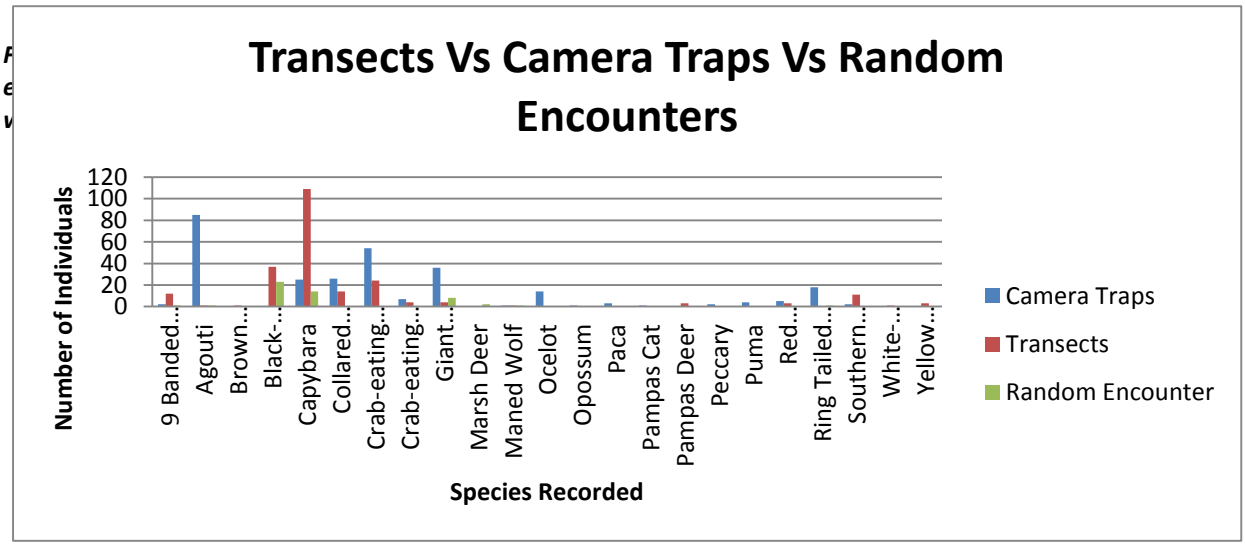
ArcMap 10.1 should be used to import GPS from transects, random encounters, scat and track transects and camera trap locations. Mapping will also used to get an area map of the reserve and Bolivia.

Results

Summary:

Each method tested varied in the number of observations and the number of species recorded. The night and day transects recorded sixteen species with two-hundred and twenty-seven observations, the camera traps recorded eighteen species and two-hundred and seventy-four observations (within two-hundred and forty-three separate viable images taken), and random observations recorded fourteen species and ninety-seven individuals. Due to lack of skill tracking the number of species recorded on the scat and track transects are debatable; however species such as Capybara (*Hydrochoerus hydrochaerus*) were not difficult to spot as they were the most abundant and displayed obvious prints. On the first transect along the river Jaguar prints were spotted, however as this animal has only been spotted once near the reserve in the past it may be an unlikely find. The Forest was the most abundant in species diversity.

During transects ten species were recorded, random encounters reported six species within the Forest (same number in the river habitat) and thirteen species were noted on camera traps within the Forest. As a method, camera traps appear to provide more data and a higher diversity of species



with a higher number of encounters. During the first night transect within the forest in San Lorenzo Owl monkeys were heard in the trees above. However their numbers were completely unknown as none were actually observed.

The figure (*Fig. 1*) above shows the species richness and number of individuals observed by camera traps and transects. Here it can be seen that camera traps show a higher number of species and have a higher number of individual recordings than transects (R-Sq=91.06%, P-Value= 0.009). The two methods shared ten species in common with possibly one Opossum and Peccary of unknown species. They also shared ten uncommon species such as; Ocelot, Puma, Ring-tailed Coati, Pampas Cat, Mouse Black Howler Monkey and more (see figure). Random encounters show more Giant Anteater than transects.

Transect Summary:

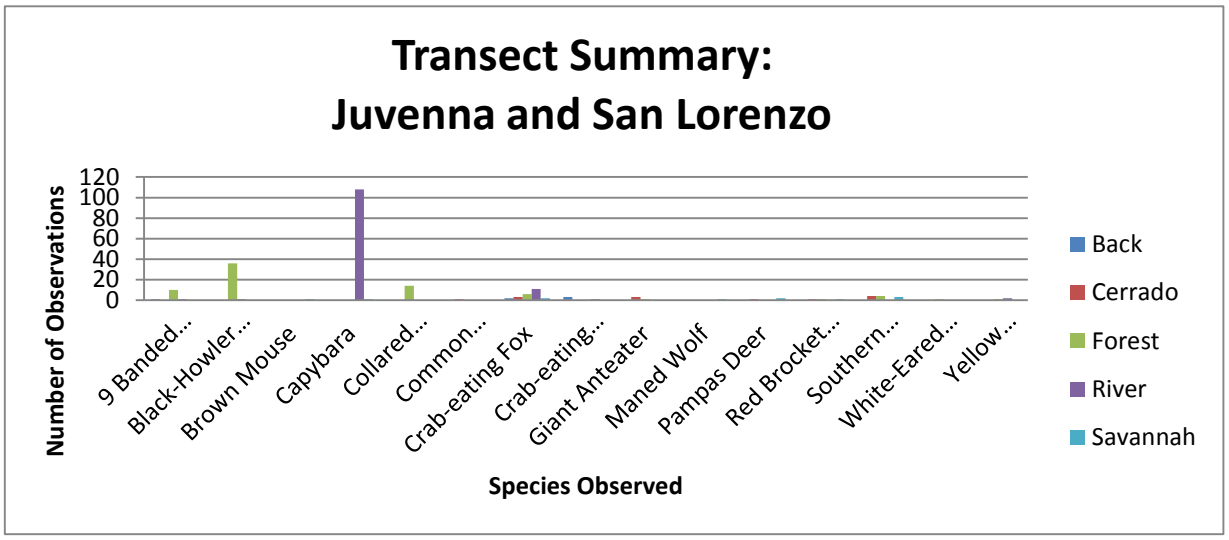


Figure 2: This graph shows the species that were recorded and where they were observed. It also shows which habitat contained the most species and which contained the highest number of species.

Figure 2 shows the number of species recorded and the number of individuals observed within each habitat type. Capybara was the most observed species as in most cases they were found in high numbers either at the river's edge or in the river itself and one sighting in the savannah. The Crab-eating Fox (*Cerodyon thous*) was found within all habitats with most sightings beside the river. A single sighting of a small brown mouse (of unknown species) moving through the short grass in burnt savannah which probably would not have been seen without the lack of tall grass. One sighting of the Maned Wolf in the savannah in Juvenna: The animal stopped and stared at us for approximately five minutes before disappearing into the longer grass. The most abundant species in the Forest were Black Howler Monkey (*Alouatta caraya*) not observed in any other habitat. Most of sightings were only made when a family moved through the trees above our heads during transects. Sometimes the exact numbers were unknown but estimations were made as accurately as possible. Giant Anteater (*Myrmecophaga tridactyla*) was witnessed in the Forest and Cerrado. One sighting was a single individual however another sighting included a mother and a juvenile together.

Distribution of Observations

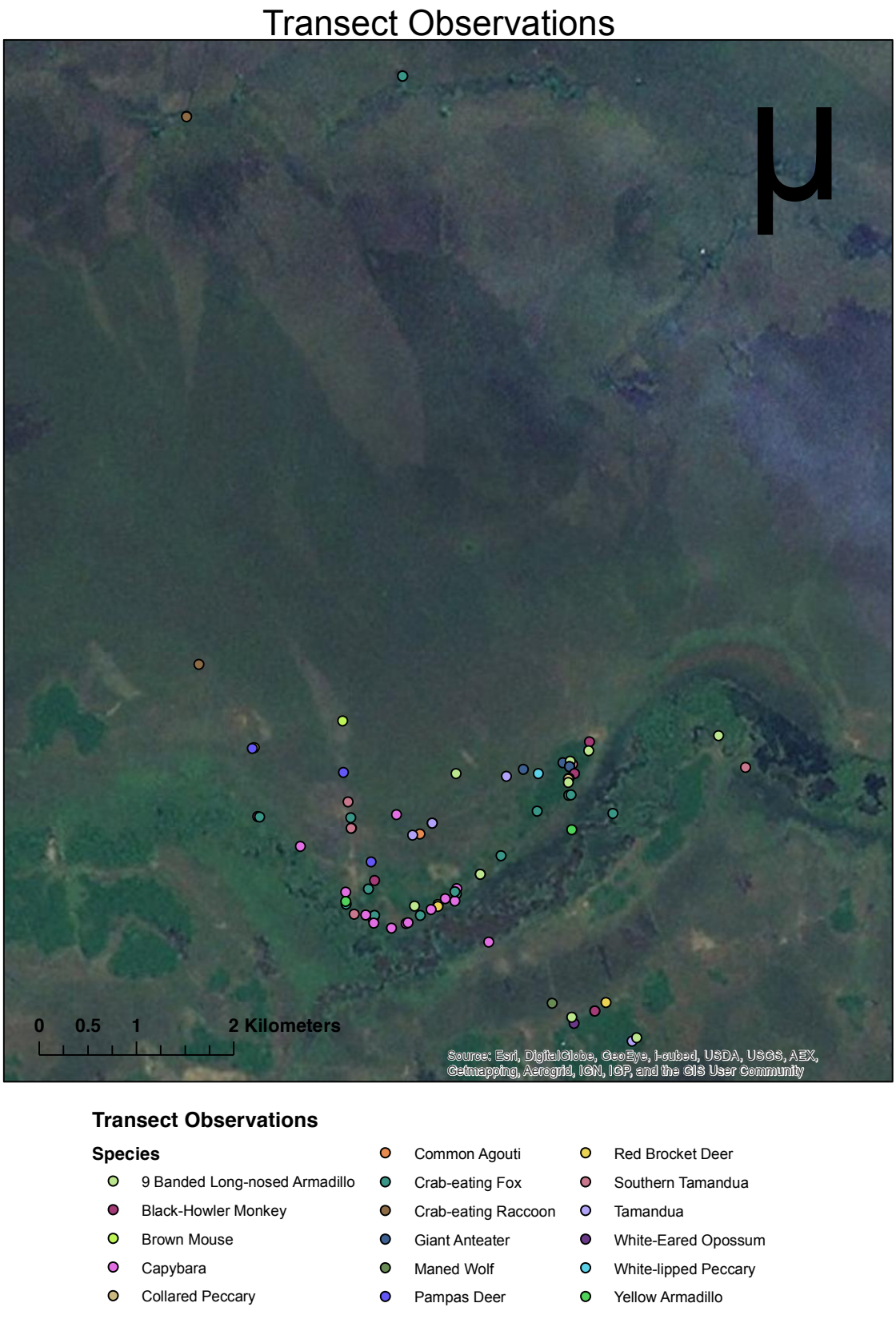


Figure 3: This map shows the distribution of species. It shows the habitat that they were observed and the general number of individuals per sighting. This map is a distribution of species observed on night and day

transects both San Lorenzo and Juvenna, including all observations pre and post fire (an error within the map shows White-lipped Peccary, however these were actually observations of Collared Peccary).

Figure 3 shows the distribution within the habitats within in the reserve. It can be seen here that Capybara are found mostly along the river and the Crab-eating Fox is found consistently throughout each of the habitats. Black Howler Monkeys were only ever observed and recorded within the Forest habitat as seen on the map above. Pampas Deer were observed in the west of the reserve within the savannah. Crab-eating Racoon (*Procyon cancrivorus*) were only observed in the back of the reserve and by the river indicated by the light pink dot on the left and top left of the map.

Camera Trap Summary:

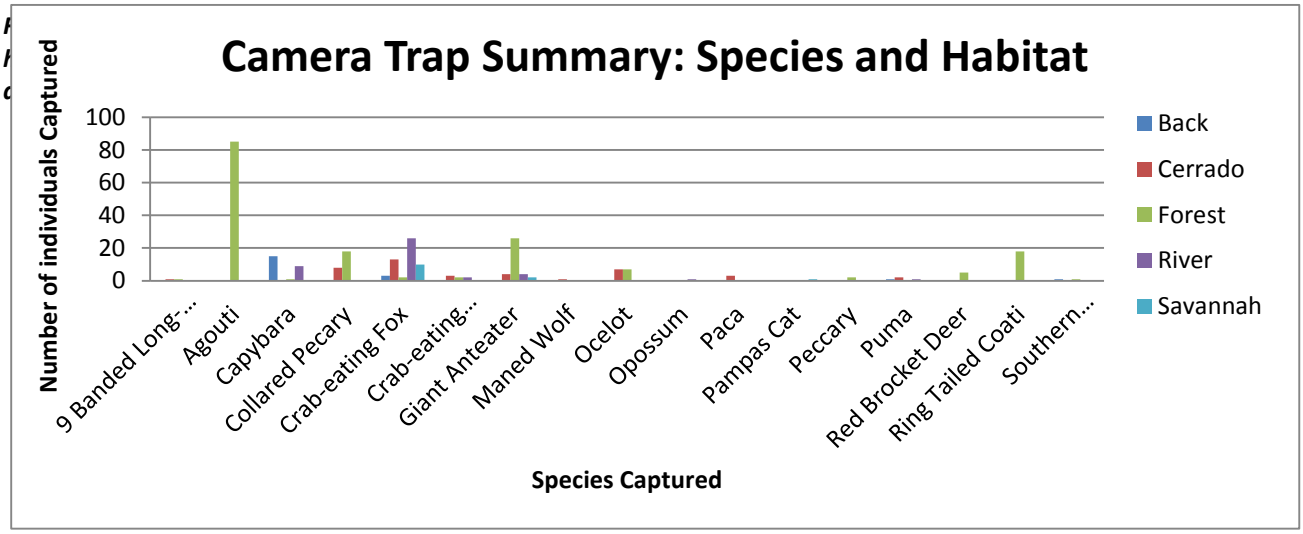


Figure 4 shows each of the species recorded on camera traps and which was most abundant within each habitat. Agouti (*Dasyprocta*) are clearly the most numerous within the Forest habitat, however due to difficulties in identifying individuals these numbers may be greatly exaggerated. Ocelot was captured in both Cerrado and Forest in equal numbers. At least four separate individuals were captured using this method, with a total of fourteen photographs taken. Giant Anteater was recorded in every habitat except at the back of the reserve. The Forest cameras recorded more captures than any other with river and Cerrado equal on number of individuals captured. At least six individual Giant Anteaters were identified within the reserve with three females with young hence why the numbers may be quite high as when one recording of an Anteater occurred it was noted as two individuals. One Maned wolf was captured on the Cerrado path with no tail. Crab-eating Fox were more numerous at the river but due to difficulties in identifying individuals their numbers may again be exaggerated here. They were found within all habitats with the least captures at the back of the reserve (three individuals). Puma was recorded at the river, Cerrado and the back of the reserve. There are at least two individual Pumas on the reserve distinguished from four separate pictures taken. Two Puma were recorded on the Cerrado with one by the river and another up the back of the reserve. Using camera traps Capybara were recorded although, more capybara were recorded at the back of the reserve and less in the river. Pampas Cat (See *Ref. Pic 6*) was recorded in the savannah after the fire and is the first image to be taken of this cat within the reserve.

Random Encounter Summary:

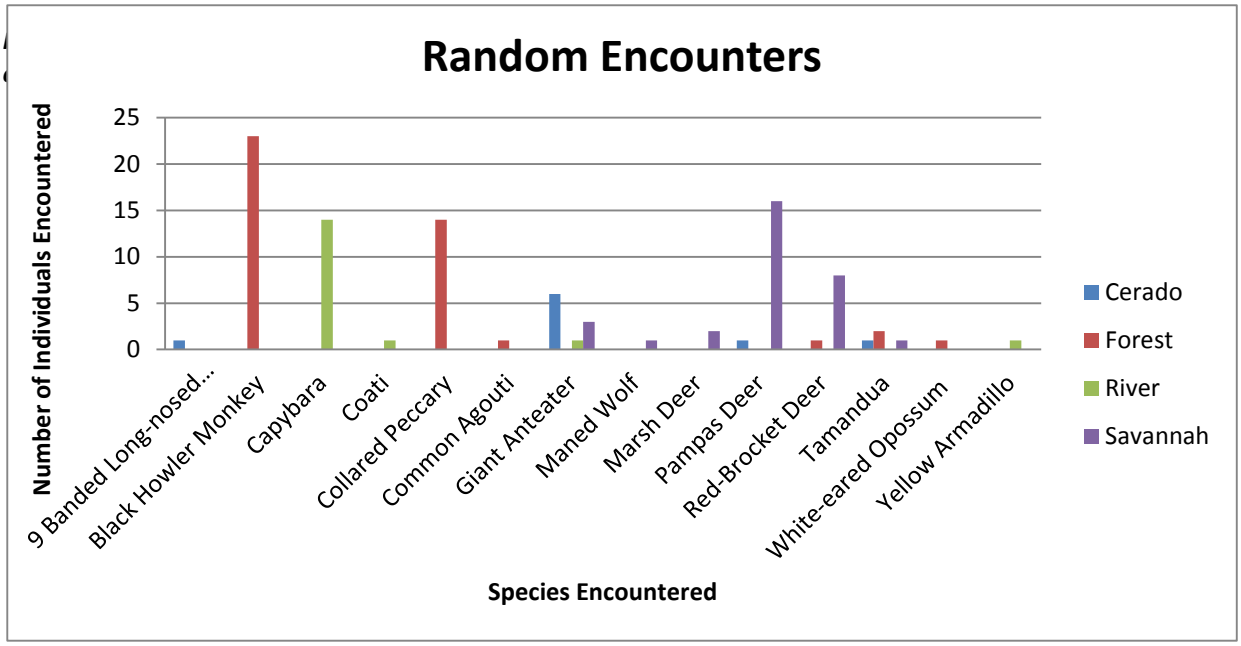


Figure 5 shows which species were randomly encountered the most and in which habitat they were observed. From this graph it is seen that Collared Peccary (*Pecari tajacu*), Pampas Deer and Capybara were encountered almost equally in their preferred habitats, with the number of individuals being similar. Black Howler Monkeys were encountered most often as when walking through any Forest, they were heard first and then spotted. After some time it became apparent that in each Forest there was either a single family or two families which were being continuously sighted and thus records of individual encounters of these animals were stopped as numbers would have been very high and not representative.

Distribution of Observations

Figure 6 shows the distributions of each of the random encounters and which habitat each encounter occurred. From this map it can be noted that most sightings were within the Forest with Black Howler Monkey being the most prevalent. However, within Juvenna (South of the River) there are 2 points which show that the Black Howler Monkeys are by the river`s edge, this may be due to a failure in reading the GPS point correctly. Giant Anteater was spotted along the Cerrado path at different points and one individual was also spotted in Juvenna within the Forest.

Scat and Track:

The most abundant species seen on these transects was Capybara by the river (See *Fig. 7*). Their tracks and scat are very easy to spot as they are made in soft mud at the river's edge during flooding. Cat species were noted throughout the reserve however the exact species are unknown. Jaguar tracks were confirmed along the river seemingly walking to and from the river's edge back towards the Forest. Crab-eating Fox and Crab-eating Racoons were other tracks quite abundant and easy to identify. Both were noted in the savannah and the river edge. Canine tracks were spotted in Juvenna however the likelihood that these were from a wild animal is very unlikely. The canine tracks were most likely to belong to domestic dogs from ranches nearby or from Juvenna itself. Overall species identified from track and scat transects are very varied and not a viable method of determining species abundance within an area.

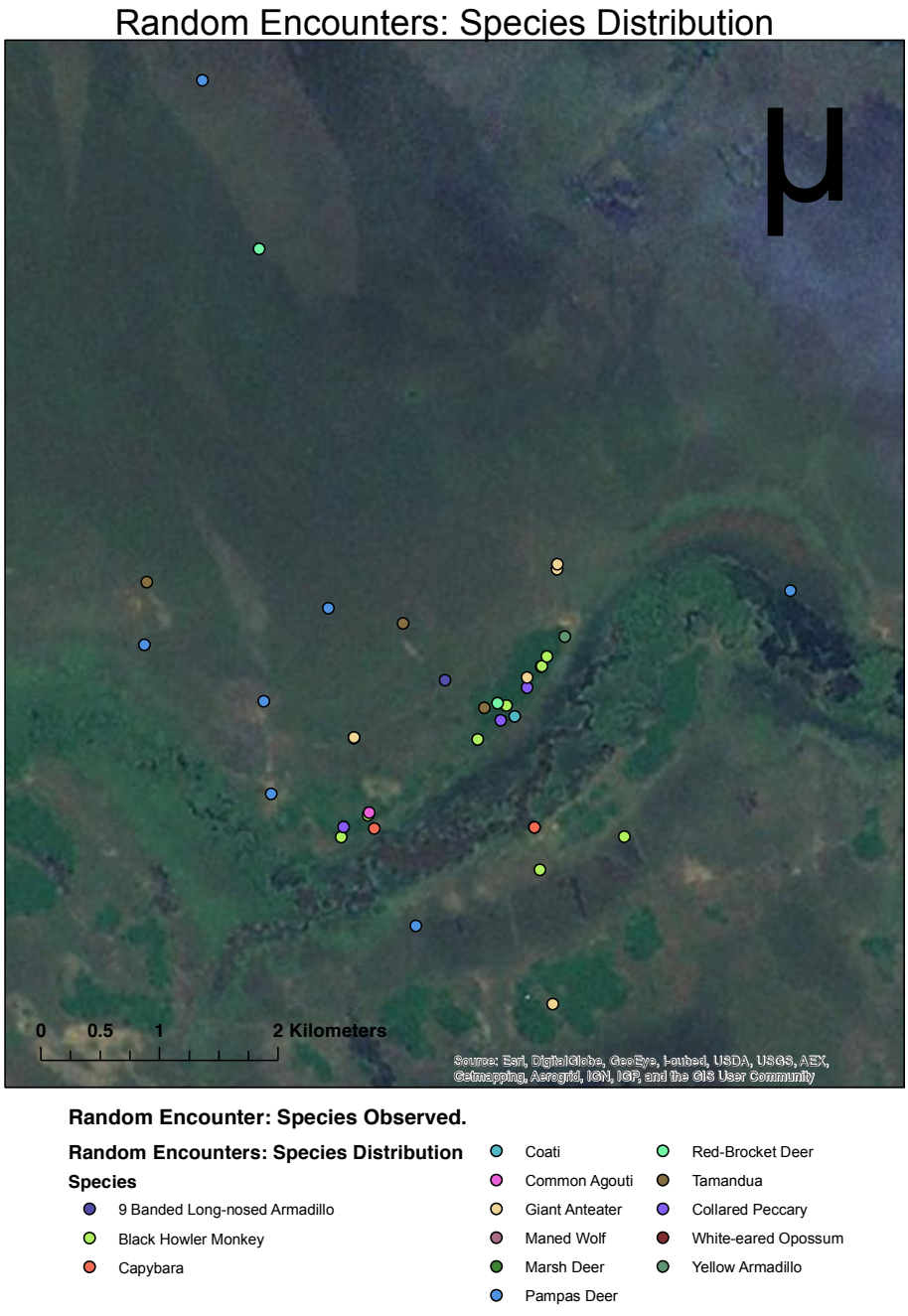


Figure 6: A map showing the distribution of all randomly encountered species and which habitat they were noted. It includes data from both pre and post fire.

Figure 7: A map showing the distribution of species tracks and scats. Some species were not identified and are marked as a question mark (?).

Abundance summary- Transects:

Figure 8 shows the mean abundance of species per habitat. Within the Forest habitat Black Howler Monkey appeared to the most abundant species by a large amount. The back of the reserve showed that the most abundant species was the Crab-eating Racoon with the Crab-eating Fox being close behind. The most abundant species in the Cerrado is the Southern Tamandua (*Tamandua tetradactyla*) with Giant Anteater and the Crab-eating Fox being level. Capybara was the most abundant species in the river habitat by a large factor. Southern Tamandua was also the most abundant species in the savannah with Pampas Deer being close behind.

Figure 8: Shows the abundance of species within each habitat. This includes data from pre and post fire, and both locations.

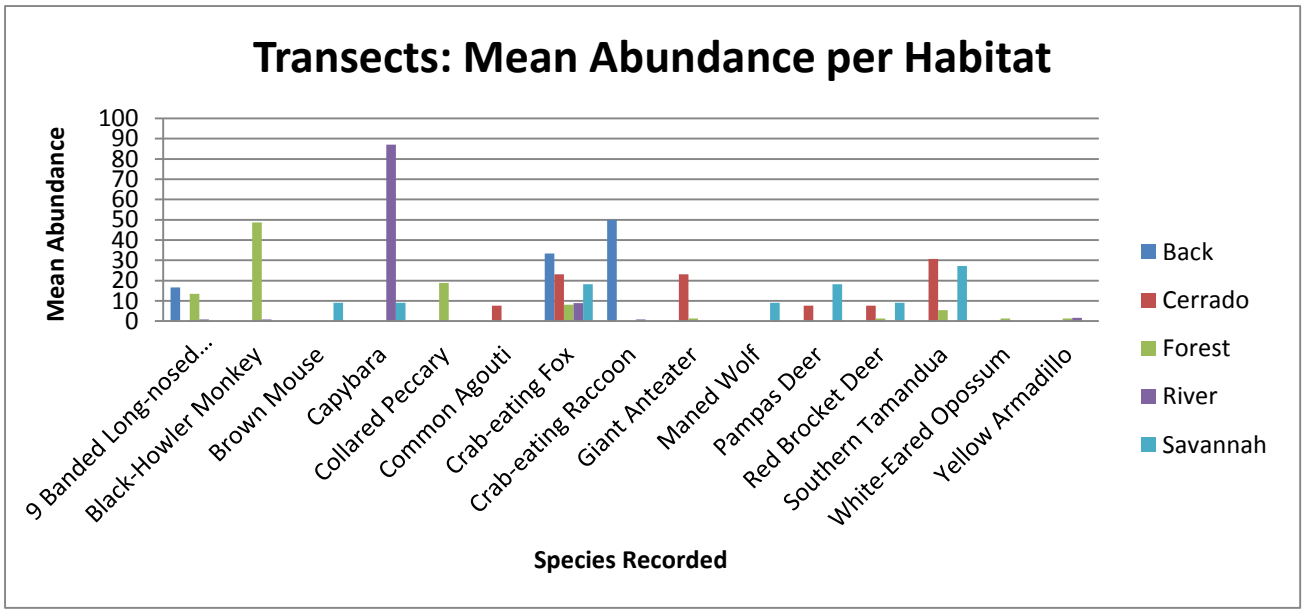
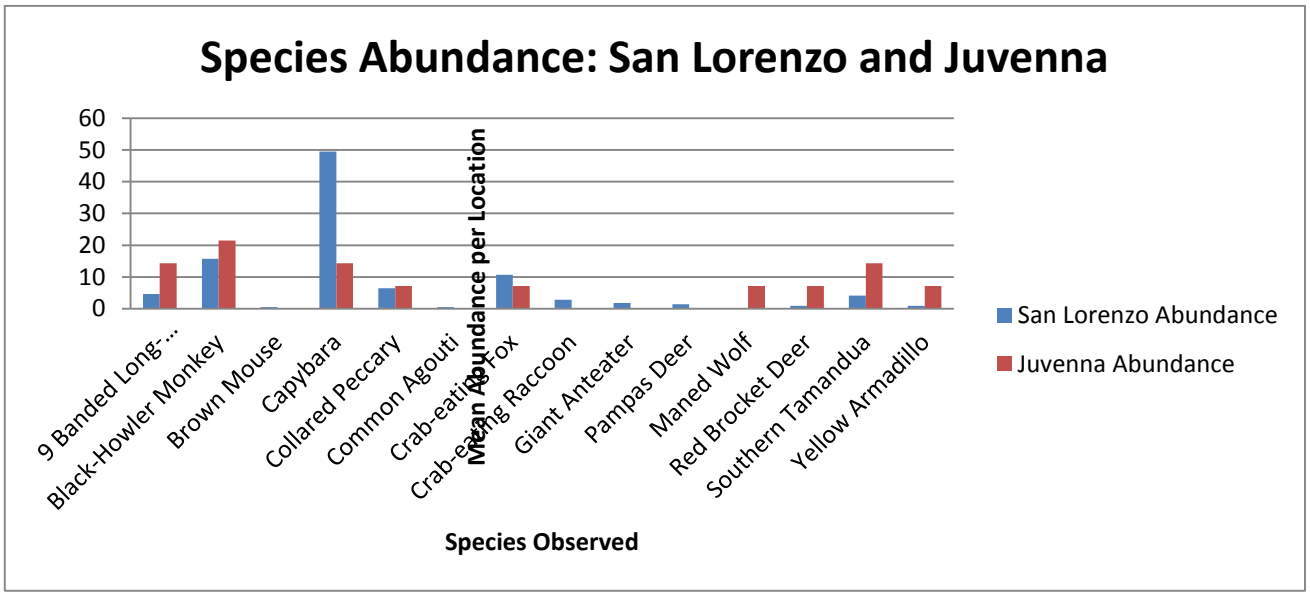


Figure 9: This bar graph shows the most abundant species within transects of San Lorenzo and the most abundant species in Juvenna. This is not a comparison.



The most abundant species in San Lorenzo according to transects (*Fig. 9*) is Capybara with no other species having similar in percentage abundances. Black Howler Monkey is the next most abundant within San Lorenzo but is not close to the mean abundance of Capybara. Crab-eating Fox is the next most abundant species with Southern Tamandua, Giant Anteater, Pampas Deer and both Armadillo species having a low mean abundance.

The most abundant species in Juvenna is the Black Howler Monkey with 9 banded Armadillo (*Dasypus novemcinctus*), Capybara and Southern Tamandua having a very similar Percentage mean abundance.

Abundance Summary- Camera Traps

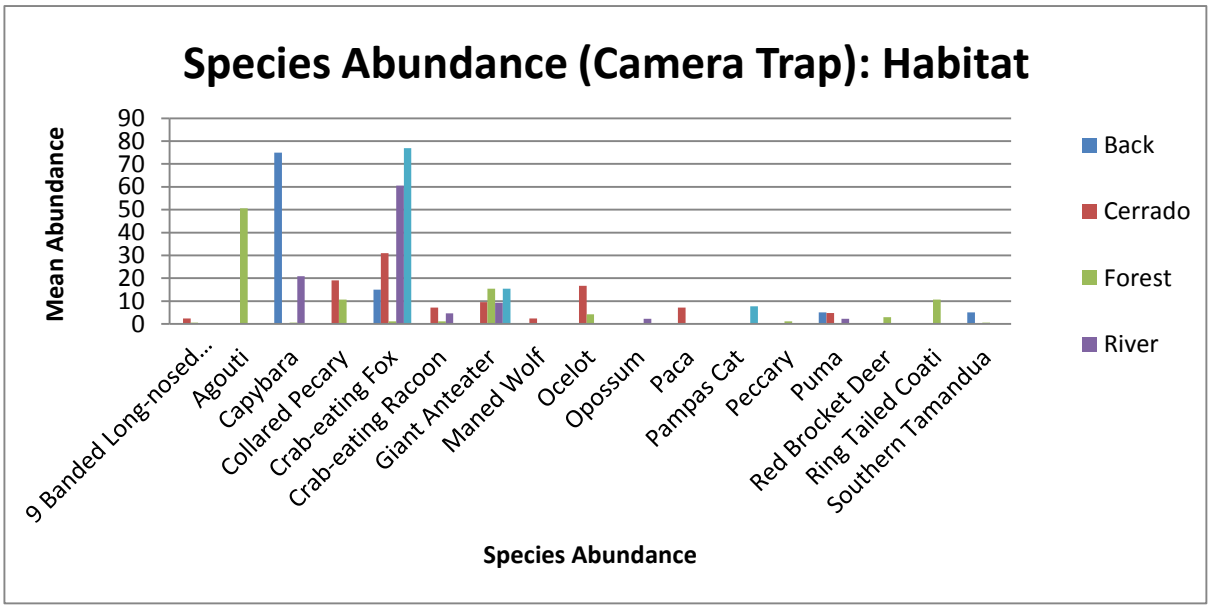


Figure 10: This bar graph shows the species mean abundance per habitat with camera trap data. This includes pre and post fire data, also including both San Lorenzo and Juvenna.

Figure 10 shows which species is most abundant within each habitat. At the back of the reserve Capybara are the most abundant species as they had the highest individual counts. Although it was the most abundant species at the back it was not so abundant in any other habitat type. In the Cerrado the most abundant species was the Crab-eating Fox with Ocelot and Collared Peccary close behind. Ocelot had a very similar mean abundance as the peccary and was more so than Puma. Within the Forest Agouti were the most abundant species by far with Giant Anteater, Peccary and Coati (*Nasua nasua*) having a very low mean abundance in comparison. Crab-eating Fox was the

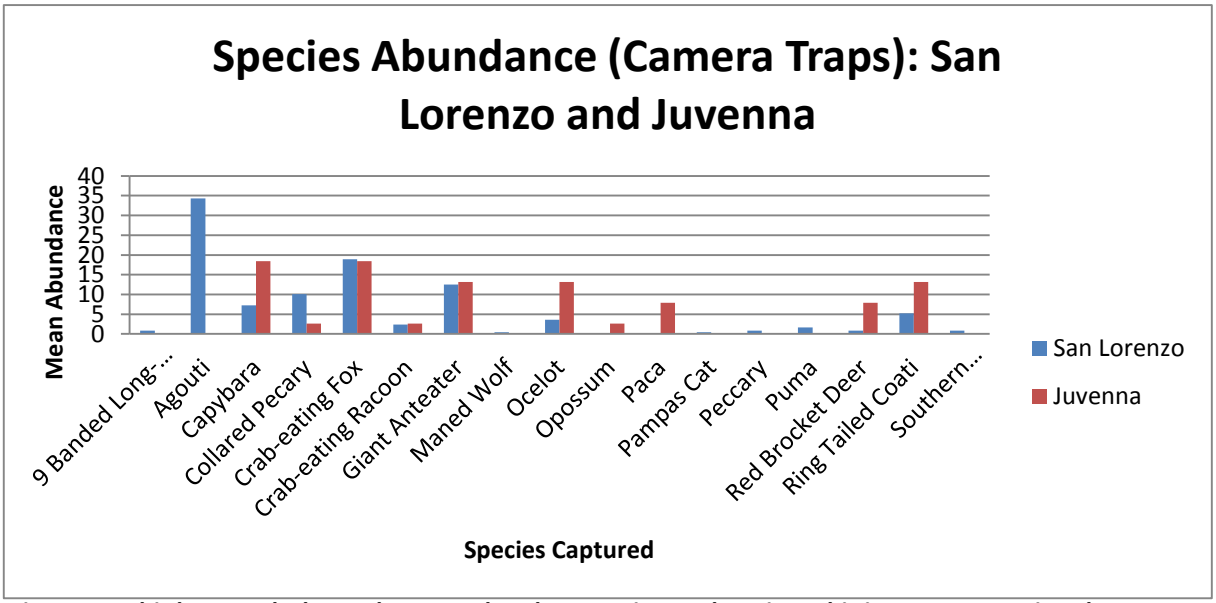


Figure 11: This bar graph shows the most abundant species per location. This is not a comparison between San Lorenzo and Juvenna.

most abundant species at the river with Capybara being three times less abundant. The Crab-eating Fox was also the most abundant species in the savannah. Giant Anteater has a very similar mean abundance between most habitats and the Crab-eating Fox has the highest mean abundance throughout all of the areas that were studied.

Figure 11 shows the species abundance with camera traps between the two locations involved in the study. Agouti has the highest mean abundance in San Lorenzo with Crab-eating Fox is half as abundant. Giant Anteater had the third highest mean abundance within San Lorenzo. Pampas cat, Peccary, Tamandua and Armadillo all have a very low mean abundance. Juvenna showed to have an almost equal mean abundance throughout all the species observed. Giant Anteater and Ocelot had the highest mean abundance behind Capybara and Crab-eating Fox. Collared Peccary and Coati both had very low mean abundances within Juvenna however the Opossum has the lowest (represented 2.5% of species observed).

Cattle Disturbance:

Transects

Figure 12: This bar graph is a comparison between San Lorenzo and Juvenna to see whether species diversity is

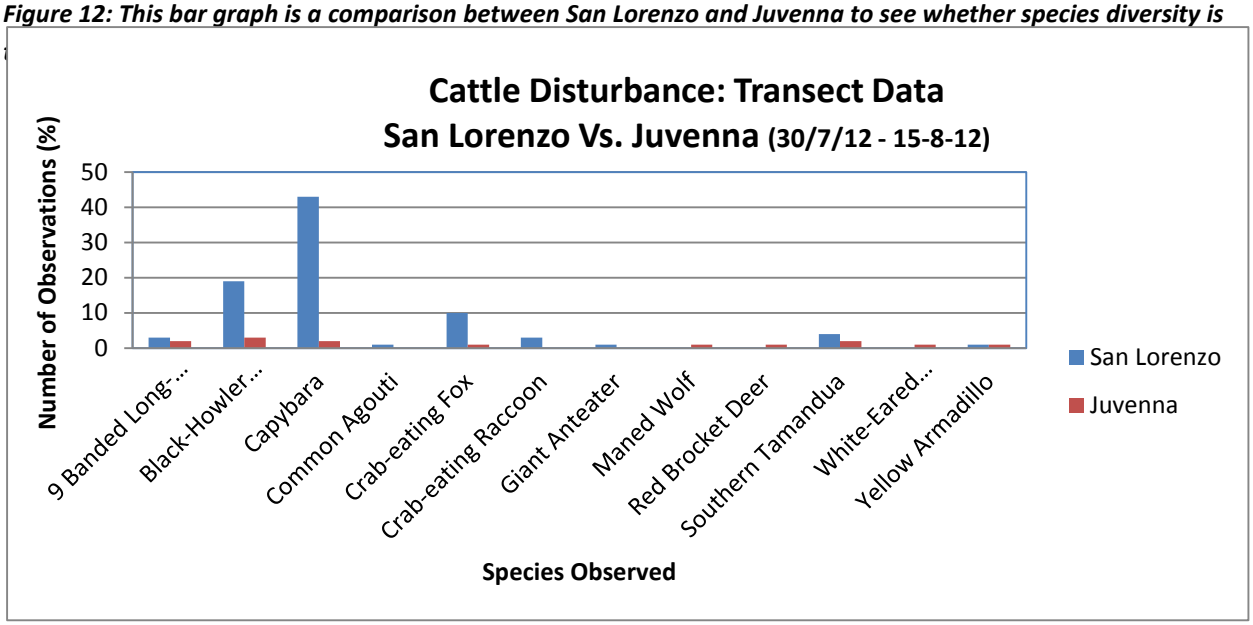


Figure 12 clearly shows that San Lorenzo (no cattle present) has a higher species diversity and higher overall abundance. However statistical tests show this not be as significant despite what the graph shows (R-Sq=72.41%, P-Value=0.204). It is still slightly significant even with a high P-value there is a high percentage chance that there is statistical proof that in an area without cattle, species diversity is higher than an area containing cattle.

Figure 13 shows the differences in species mean abundance between locations. The main difference that can be seen is Capybara as it has a much higher mean abundance in San Lorenzo that Juvenna. No differences are evident in *Figure 13* as the abundance levels are similar for all species. Statistical

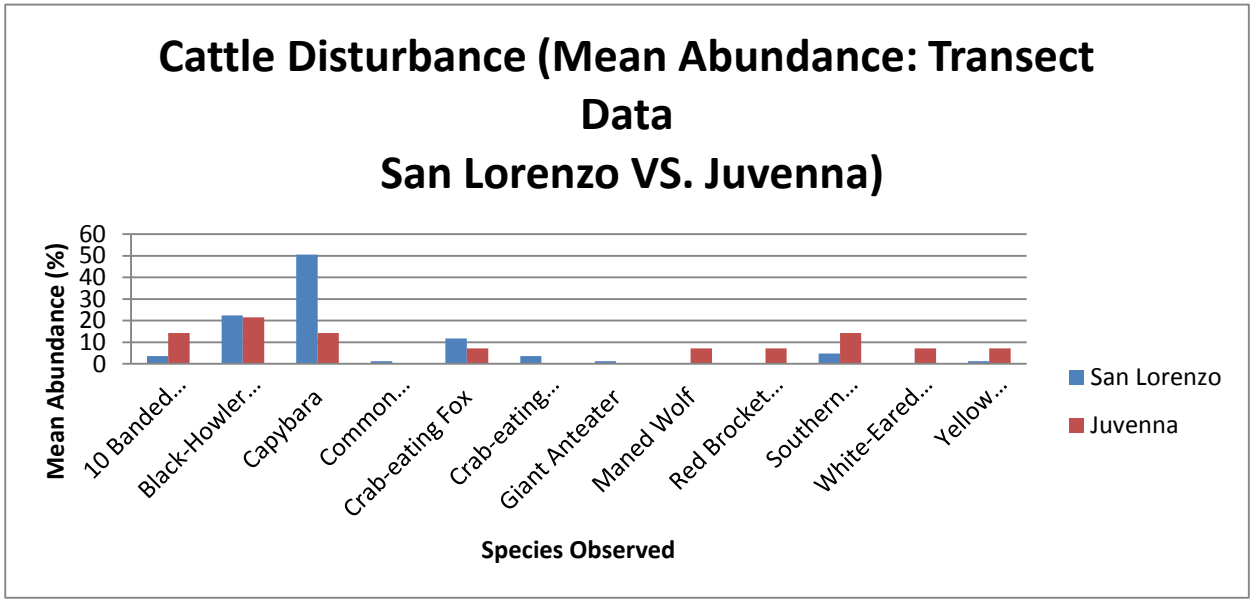


Figure 13: This bar graph shows the differences in mean abundance of all species observed within the time of this study.

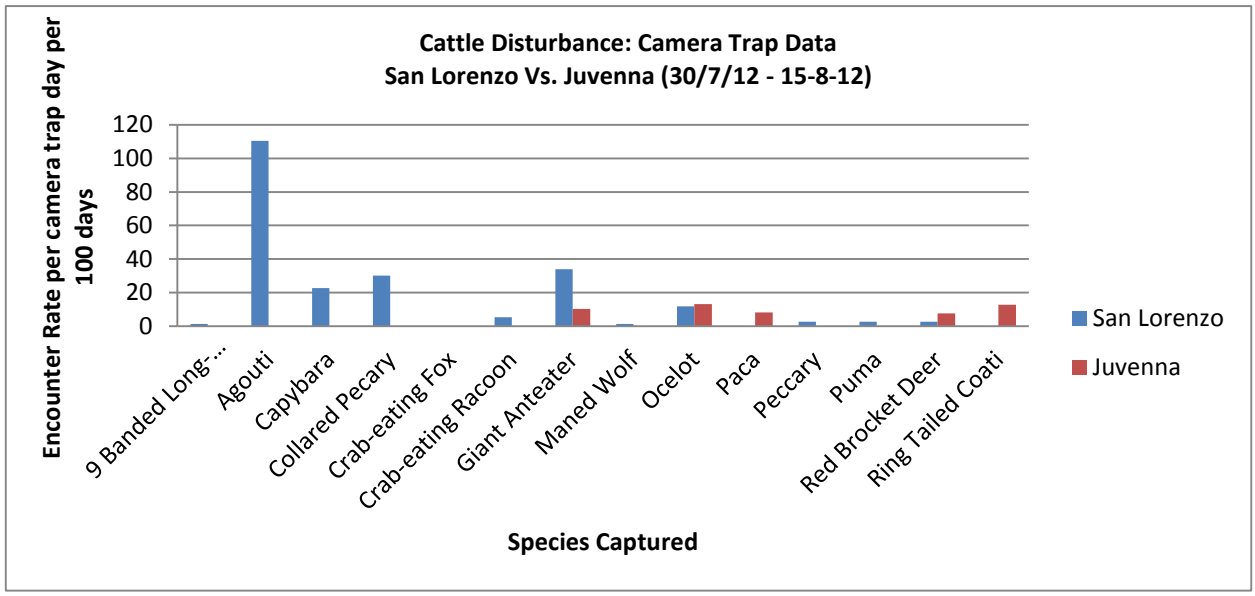


Figure 14: The bar graph shows the encounter rate and species diversity in relation to presence of cattle. San Lorenzo is without cattle and Juvenna with cattle.

analysis proves that there is no significant difference in abundance in an area with or without cattle (R-Sq=72.41%, P-Value=0.204). Transects also show there is not much significance between cattle and no cattle in these areas.

Cattle Disturbance: Camera Traps

Figure 14 shows that there are more species within San Lorenzo than in Juvenna, where there are no cattle there is higher species diversity and a higher encounter rate. However there is a low statistical significance to say this is the case (R-Sq=69.74%, P-Value=0.713). The statistical significance when the data from San Lorenzo was divided by two is slightly more significant than in *Figure 14* above (R-Sq=84.81%, P-Value=0.390) (see methods: so San Lorenzo has an equal effort to Juvenna) (see *Figure 15*). With a P-value of 0.713 there is no significance between the difference in species and encounter rate when in the presence or without the presence of cattle. *Figure 14* shows that in an area of no cattle (San Lorenzo) there is a higher species diversity. A total of twelve species were captured in San Lorenzo whereas in Juvenna only five species were captured.

Looking at *Figure 16* there is still evidence that there is a difference between both locations. In Juvenna more Ocelot were captured and had a higher encounter rate than San Lorenzo. This also includes The Ring Tailed Coati (or South American Coati) in that during this study they were not captured in San Lorenzo. Red Brocket Deer also had a much higher encounter rate in Juvenna than San Lorenzo. The mean abundance in Juvenna is higher than San Lorenzo (*Figure 16*) although again there is low statistical significance (R-Sq=89.05%, P-Value=0.501).

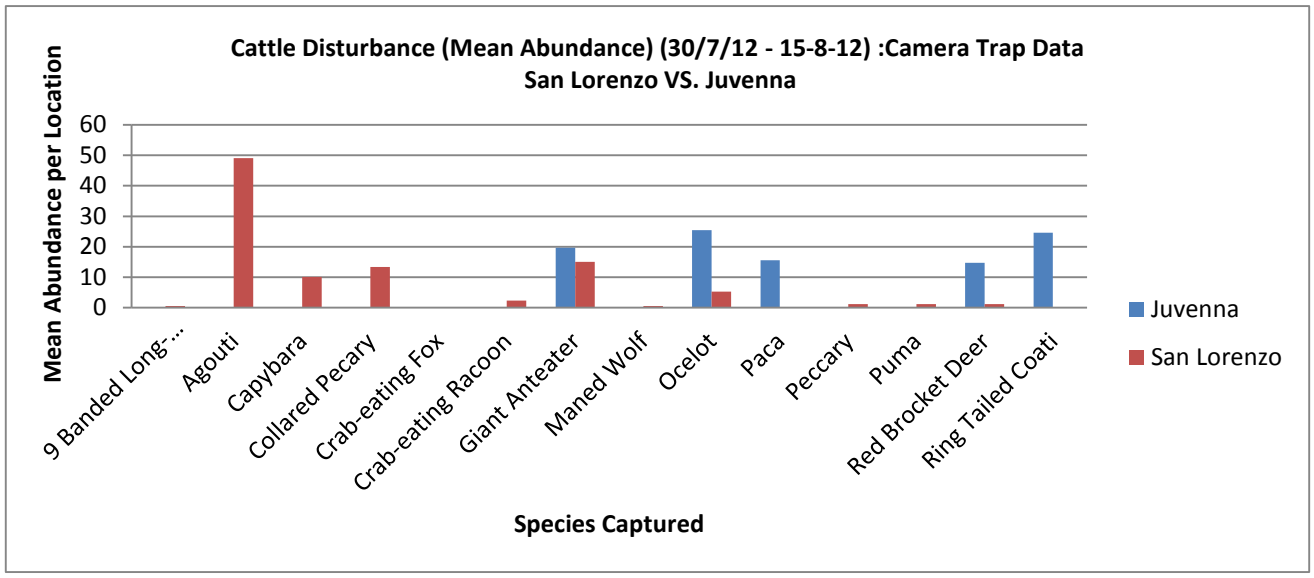
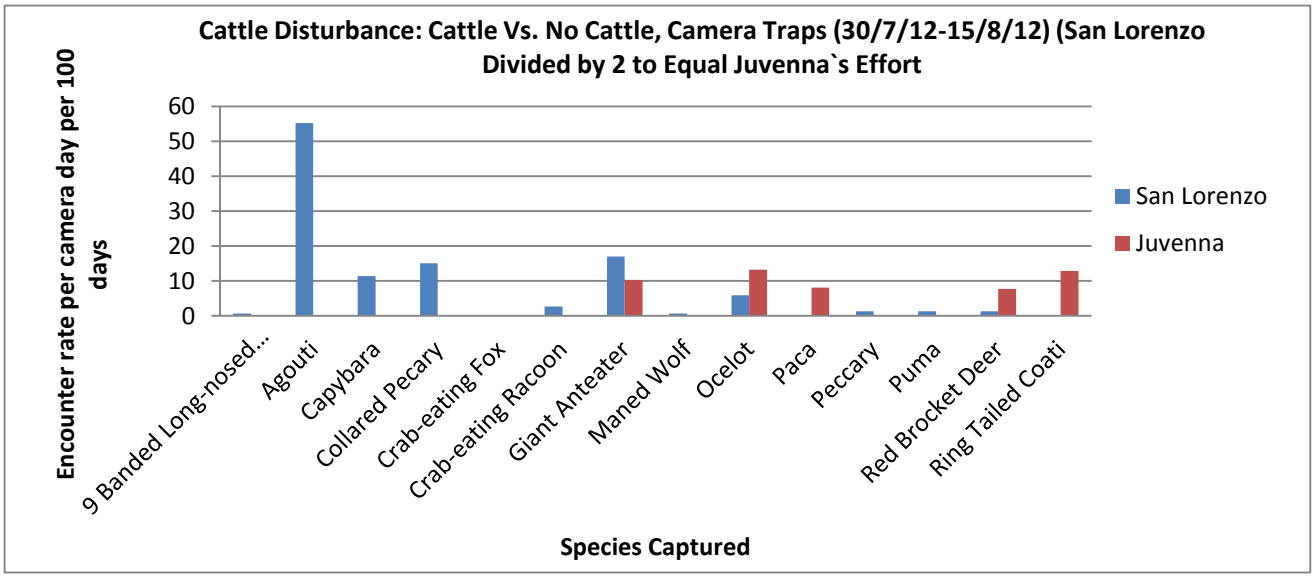


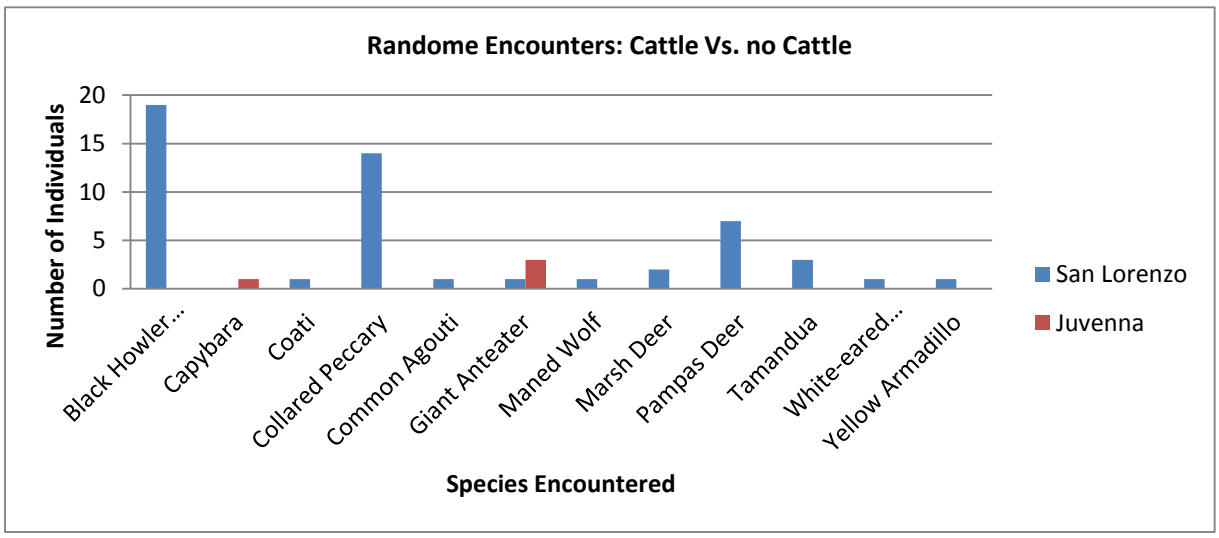
Figure 16: This bar graph shows the same data from Figure 14 however, San Lorenzo data was halved to equal the effort applied in Juvenna.

Figure 15: This bar graph shows the percentage mean abundance of San Lorenzo (no cattle) compared to Juvenna (with cattle) The encounter rate was used to calculate the percentage mean abundance of species within sample.



Cattle Disturbance- Random Encounters:

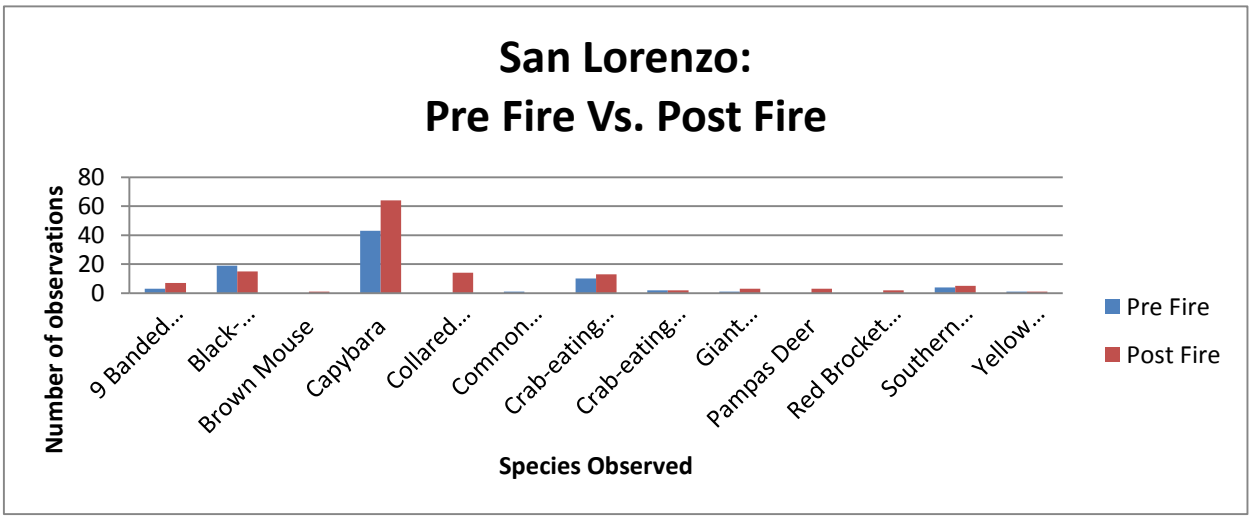
Figure 17: A bar graph showing the species randomly encountered in San Lorenzo and Juvenna.



Random encounters showed some statistical significance in species richness (P=0.056). *Figure 17* shows that in San Lorenzo there is a higher chance of encountering an animal randomly than in Juvenna. With a P-value of 0.056 it can be seen that there is some significance in that there is higher chance that a random encounter will occur in San Lorenzo than in Juevnna. There were eleven species encountered in San Lorenzo whereas in Juvenna only two species were encountered, meaning that there is a much higher species abundance and diversity within an area of no cattle.

Fire Disturbance- Transects:

Figure 18: A bar graph showing Pre VS. Post fire in San Lorenzo. It shows the number of individuals observed during transects and also the species. This graph is a species diversity comparison to see if there is more species pre fire than post fire.



Results showed that before the fire occurred (pre-fire is anything from the 12-8-12 and earlier) that nine species were observed during night and day transects. Post fire (any observation from the 13-8-

12 until end of study) showed that there are four (thirteen in total) more species observed. Therefore there is a slightly higher species richness post fire (see *Fig. 18*).

There is a very strong statistical significance that supports the hypothesis that there will be changes in species diversity after a fire (R-Sq=99.4%, P-Value= 0.0001). After the fire occurred more Crab-eating Foxes were spotted, less Black Howler monkey, more Nine Banded Long-nosed Armadillos and a large increase in the number of Capybara encountered. Pampas Deer were documented on San Lorenzo for the first time on night transects after the fire and more Giant Anteater were also spotted. During pre-fire transects a total of eighty-four individuals were documented; whereas during post fire transects a hundred and thirty individuals were counted. This is a large increase in abundance of animals after the fire.

Figure 19: This bar graph shows the mean abundance in San Lorenzo comparing between pre and post fire.

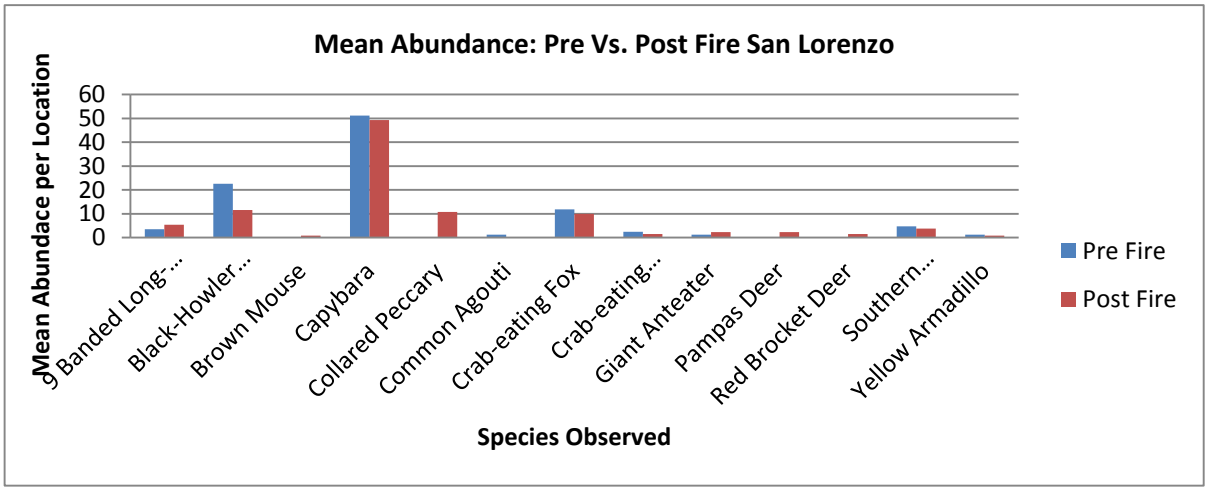


Figure 19 shows the changes in abundance post fire and how it has been affected. Through statistical analysis it was found that there are changes in abundance post fire (R-Sq=99.4%, P-Value=0.0001). From the graph above it can be seen that in the case of Black Howler Monkey, Capybara, Crab-eating Fox and Racoon, Southern Tamandua and Yellow Armadillo their abundance has decreased after the fire. However, Long-nosed Armadillo and Giant Anteater increased in abundance. Some species that were not previously seen on transects were observed after the fire occurred such as Pampas Deer, Brown Mouse, Collared Peccary and Red Brocket Deer.

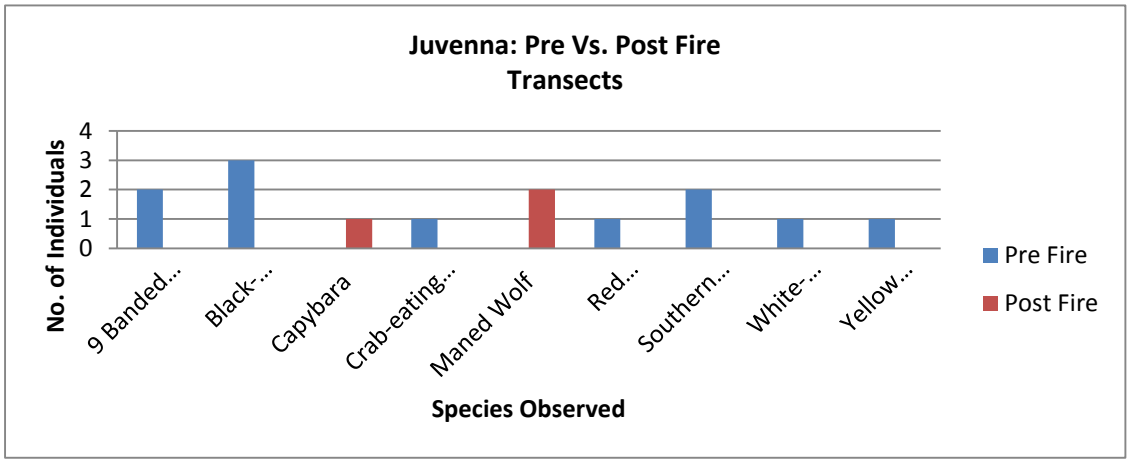


Figure 20: This bar graph shows the species observed pre and post fire within Juvenna.

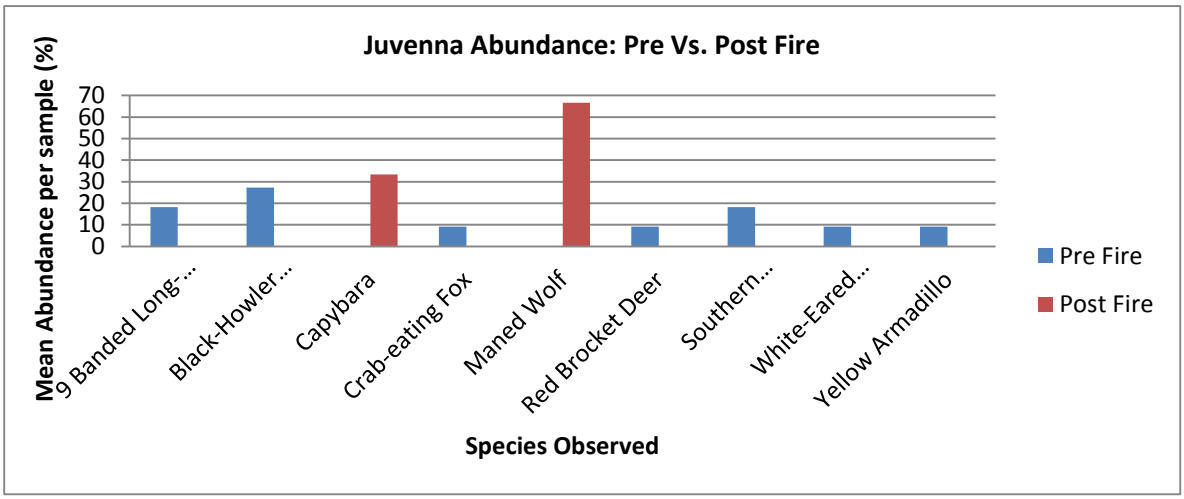
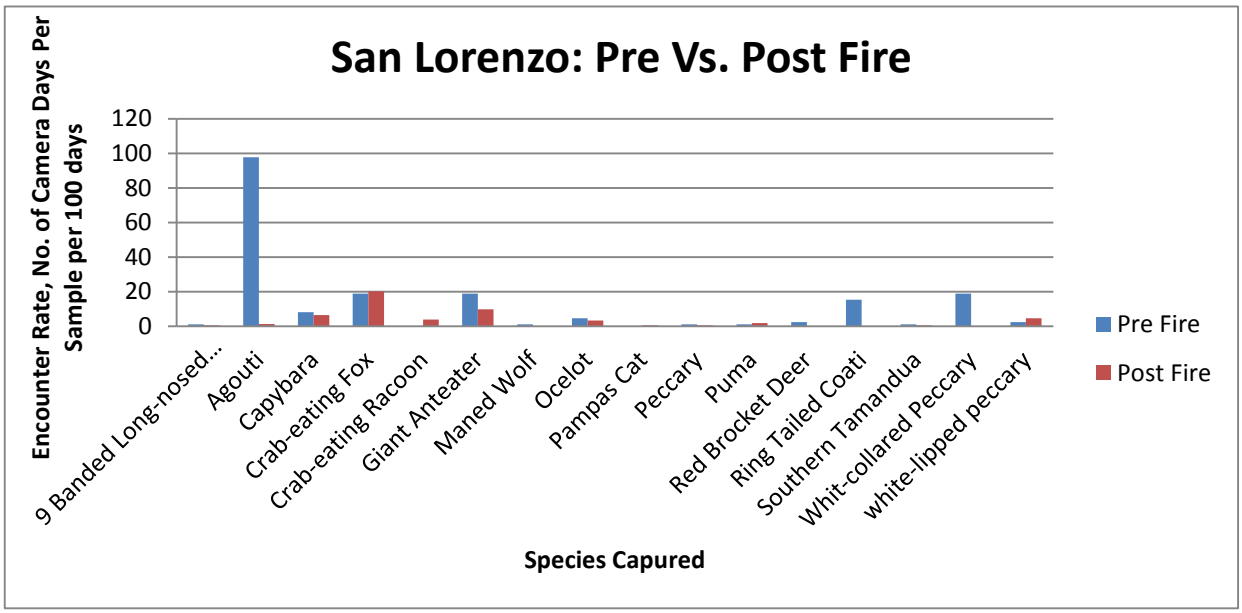


Figure 21: This bar graph shows the changes in abundance in Juvenna, pre to post fire during transects.

In Juvenna the number of species encountered during transects after the fire showed a large reduction (See *Fig. 20*). Before the fire seven species were observed whereas after the fire only two were noted. There was also very little statistical proof to say that the fire had any effect on Juvenna (R-Sq= 50.84%, P-Value= 0.119). The abundance shows apparently no change after the fire with statistical analysis despite the graph showing that species diversity changed and was largely reduced (R-Sq= 50.84%, P-Value= 0.119) (See *Figure 21*).

Fire Disturbance: Camera Traps

Encounter Rate



Before the fire (12th August and earlier) in San Lorenzo a total of fourteen species were captured using

Figure 22: This bar graph shows the species and the encounter rate in San Lorenzo, Pre Vs. Post fire.

camera traps. After the fire (13th August until end of study) a total of twelve species were documented in San Lorenzo with species that were not captured pre-fire (see *Figure 22*). In *Figure 22* it can be seen

that there is a very clear change in species diversity. After the fire Red Brocket Deer, Collared Peccary, South American Coati (Ring-tailed Coati) and Maned wolf were not documented. Pampas Cat and Crab-eating Racoon were new species noted after the fire. Comparing pre and post fire there are clear decreases in the number of animals captured. Using GLMs it is very clear that these differences are very significant meaning the fire had a large effect (R-Sq= 97.19%, P-Value= 0.001).

In Juvenna there were four species noted after the fire that were not captured before the disturbance (see *Fig. 23*). Species such as Giant Anteater were not seen in Juvenna before the disturbance but were captured a large number of times after the fire. Ocelot declined slightly in numbers and the encounter rate. Paca (*Ciniculus*) increased slightly and capybara decreased. However there was no statistical significance of any proof that the fire caused any changes in the species encounter rate and diversity (R-Sq=81.32%, P-Value= 0.151). Fire did not occur in the

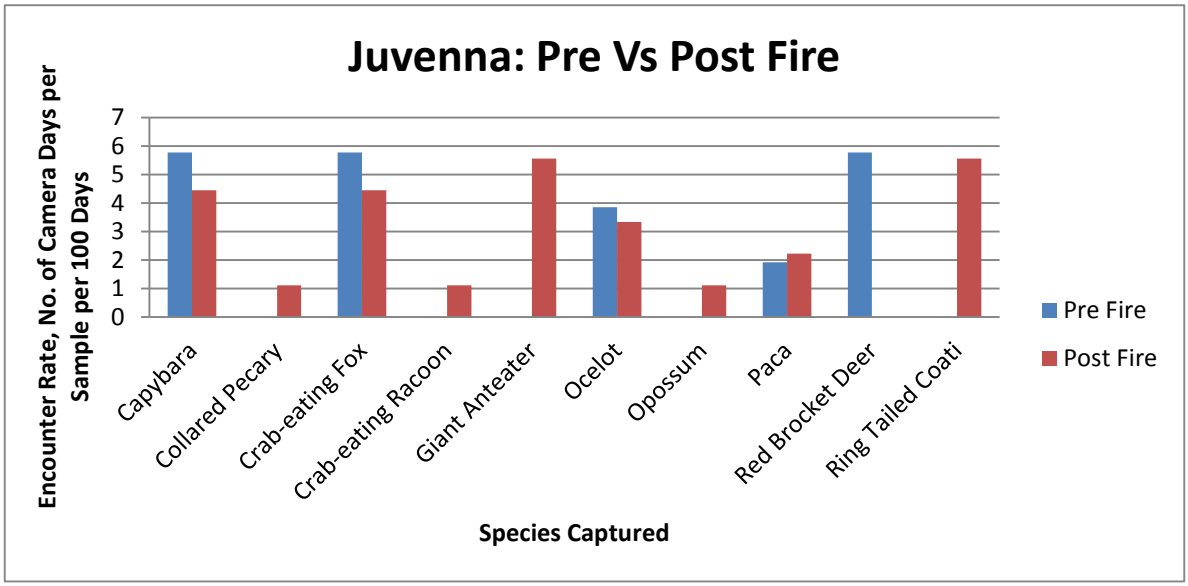


Figure 23: A bar graph showing the comparison between pre and post fire in Juvenna using camera trap data and their encounter rates.

Camera Trap- Abundance: Pre Vs Post Fire

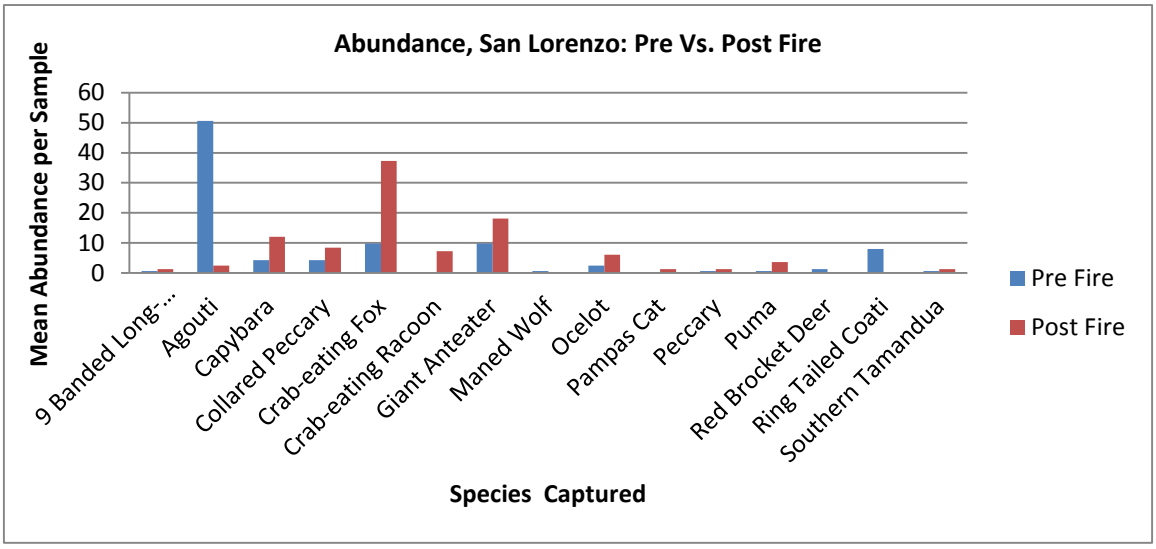


Figure 24: This bar graph shows the changes in abundance within San Lorenzo after the Fire disturbance. This graph is using the encounter rates to calculate the abundance (see methods).

It is clear in San Lorenzo that the most abundance species before the fire is Agouti which saw a dramatic decline after the fire (see *Figure 24*). Crab-eating Fox showed a very large increase in the number of captures after the fire had passed and became the most abundant species. Species which also increased in abundance after the fire was Giant Anteater, Puma, Collared Peccary, Ocelot and Capybara. The change in abundance within San Lorenzo due to fire is very significant with high statistical proof (R-Sq=97.19%, P-Value= 0.001).

In Juvenna there were changes noticed after the fire had occurred however, it is not as dramatic as in San Lorenzo (See *Fig. 25*). Three species were of equal abundance; Capybara, Crab-eating Fox and Red-Brocket Deer. All of the species just mentioned declined in abundance with Red Brocket Deer not being recorded after the fire at all. Species abundances were overall reduced by a very small factor and therefore it can be said the fire is not the reason for this change (paired T-tests showed a P- Value of 1).

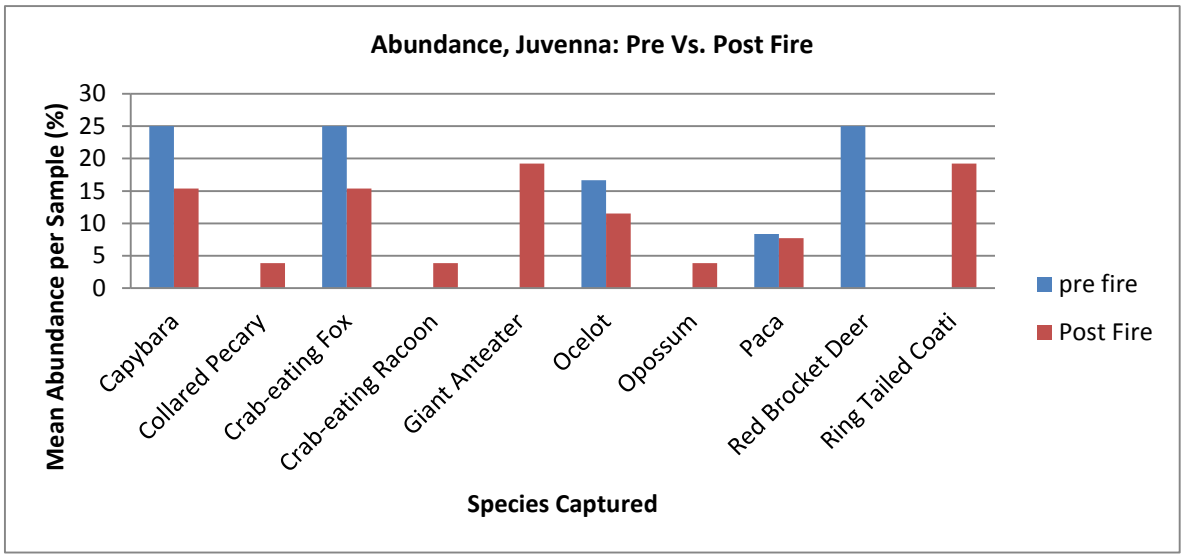


***Figure 25*: This bar graph shows the changes in abundance from pre Vs post fire in Juevnna using camera traps.**

Random Encounters:

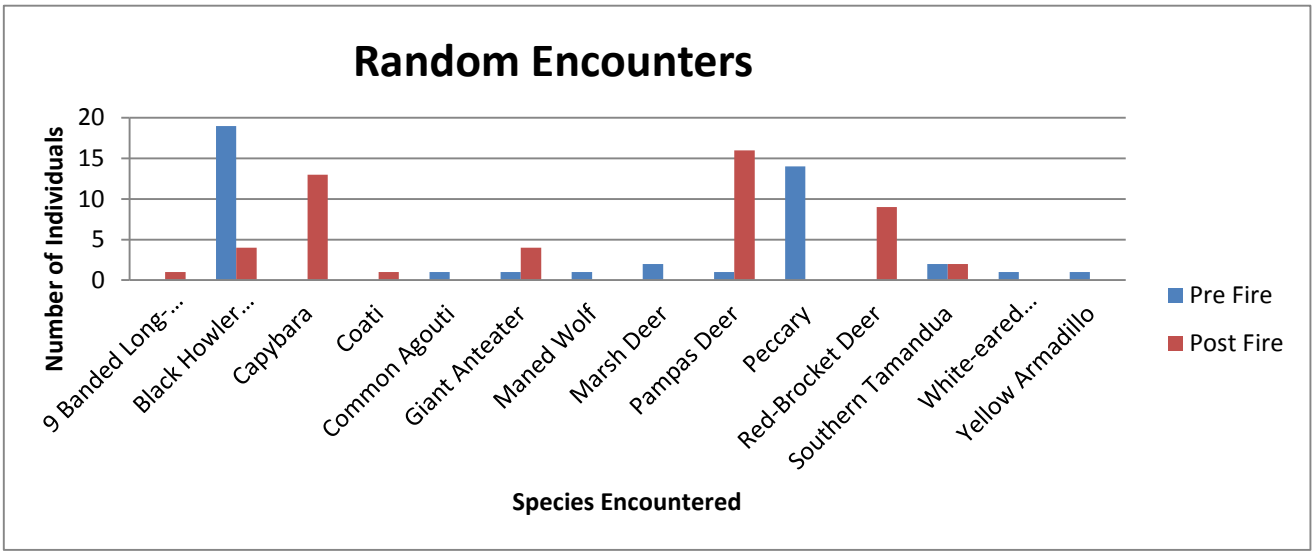


Figure 26: This bar graph shows the random encounters within San Lorenzo. Pre-fire observations are compared to post-fire observations.

Figure 26 shows the changes in random encounters after the fire disturbance. There is a large increase in the number of Pampas Deer encountered after the fire (an increase of fifteen individuals). Capybara was only randomly encountered after the fire (a total of thirteen individuals). Encounters of Giant Anteater increased after the fire (an increase of three individuals).

Discussion

Method Analysis:

The use of camera traps provided more data which included a higher number of species recorded than on scat and track transects and also night/day transects. Camera traps were the best method to use, as they were non-invasive apart from a single flash emitted when movement was sensed. They were placed in the best manor by choosing each spot carefully by looking for tracks and obvious paths within the forest, river, cerrado and savannah and at the back of the reserve. If no path was visible one was created to allow easier access to other areas or to simply make it seem more appealing to the animal. Transects on the other had were invasive and difficult as noise was always made despite trying to stay quiet, disturbing any animals nearby. During night transects, depending on habitat type, it was compulsory to stay as quiet as possible and move as slowly as possible without any talk whatsoever to reduce disturbance. In some cases this was not possible as in the forest where the ground was littered with dry leaves, rotting logs and very little visibility even with strong torches. Any animal within a close radius would either scatter off into the distance making identification impossible or animals would cease to move and stay as quiet as possible themselves. The best way to spot an animal was usually by the eye shine from the torches or when an animal moved (this is most apparent in Black Howler Monkeys). Despite this transects did show more than random observations. However, the cerrado path is very flat with low lying grass therefore allowed for stealthy movements. Many animals would use this path for easy access due to the flat grass, and the close proximity to the forest. This also applied to the savannah path where ground was also flat and debris free making it much easier to remain quiet. Transects in the river area were simple however, being out in the open would scare off any potential mammals as people were easily spotted. For example, with Capybara when individuals spotted human activity they would either ignore the transect group or run for safety into the water. This made counting their numbers extremely difficult. During transects at the back of the reserve it was not possible to walk as it was flooded for the entire period of our study and completing them on horse-back was the only way. The horses may have disturbed the wildlife in the area hence why the numbers of species and individuals observed on transects were very low (only six observations were made, see transect section in results).Scat and track transects are not included in this as neither the team nor myself have any good tracking experience. It was difficult to distinguish between cat species, dog species (in most cases they were most likely domestic dog), and many other species. This method is not useful within this study due to the high probability of errors in identification, but, may well be more useful if the researcher was an experienced tracker. Random encounters are a very useful way of gaining extra data as from my results fourteen species were encountered which is only two less than what was observed on designated transects, also it is the only method which obtained sightings of Marsh Deer.

Overall each method employed provided data that was used in some way to explain the effects of each disturbance and overall difference in species abundance and diversity in each habitat, however the best method to gain valid results are camera traps. Camera traps, as talked about in the previous paragraph, are very non-invasive and show much more representative view of the species abundance and diversity within an area.

Disturbance:

Cattle:

Capybara had an overall higher abundance in San Lorenzo than in Juvenna this could be attributed to cattle consuming and down-grazing their main food source (see *Fig. 12 &13*). The main food source for both Capybara and cattle is *Poaceae* (a true grass found throughout the planet) (R.D. Quintana. *et al*, 1998). Thus, this could be correlated to the higher numbers of Capybara seen in the San Lorenzo area where there is a healthy reed and grass species structure along the river banks.

Pampas Deer were only observed during random encounters, all sightings were circumstantial with no way to predict areas for possible sightings (*Fig. 1*6). The majority of sightings were post-fire (*Fig*. 26), most individuals observed eating new grass growth. There are two factors that could influence their numbers; In Juvenna there are hundreds of cattle which roam freely across all the habitats, domestic dogs are often found and on some occasions they will follow humans. Vehicles are frequently in use throughout the Juvenna area creating noise disturbance. The other factor is that cattle change the plant species mosaic by down grazing the dominant grasses open up niches for the less competitive species (Altesor, A. *Et al,* 2006). This can create problems for Pampas Deer which utilise tall grasses to hide and flee from danger or any threats.

This reliance on tall grass levels also applies to the Maned Wolf as they use this nice for cover whilst hunting. Maned wolf were spotted in Juvenna in one of the few areas of longer savannah grass and in San Lorenzo had a higher frequency of sightings in San Lorenzo.

In Juvenna it was observed that there were a reduced number of termite mounds compared to the numbers in San Lorenzo caused by trampling caused by cattle. Giant Anteater numbers will be affected by this as their main food source has been reduced in Juvenna. Higher numbers of Giant Anteater were observed in San Lorenzo where termite mounds are found throughout the reserve within forest islands and savannah allowing more to inhabit it (Vasconcellos. A. *et al*, 2010). Abundance levels of Giant Anteater appeared to be higher in Juvenna, but there are more sightings of individuals in San Lorenzo.

In Juvenna there is a lot more open space allowing for there to be more sightings of Ocelot than was observed in San Lorenzo. Ocelot had a higher encounter rate and much higher percentage abundance per sample than in San Lorenzo. They prefer dense cover which Juvenna lacks in comparison to San Lorenzo, which could be a reason for more Ocelot captures as they are more often observed at night in open areas. A higher percentage abundance of Agouti, a nocturnal rodent, were captured in San Lorenzo, this species is a potential prey item of the Ocelot although ocelot number appeared higher in Juvenna. This data could be a false representative of actual Ocelot numbers present as the San Lorenzo area, as mentioned above, contained denser (preferred) cover thus individuals had less need to venture into open areas which are more common in Juvenna. This false representation could be accounted for by the lack of sufficient data, the collection of which was severely influenced by time constraints. Therefore data gathered is not sufficient to say that there are more Ocelot in Juvenna.

When looking at cattle disturbance and the possible effects upon native mammal species diversity and abundance a clear effect can be seen. It appears that within areas grazed by cattle marked differences in species numbers can be seen. The most notable example is that of the Capybara which in every method employed: camera trap data, random encounters and transects showed markedly higher numbers in San Lorenzo (*Fig. 12, 13, and 14)*. This can correlated with the main food item of the Capybara *Poaceae* grasses*,* which coincidentally is one of the preferred foods of cattle. Thus these lower numbers of Capybara in Juvenna correlate with the lack of a sustainable food source for a large population as seen in San Lorenzo.

At the back of the reserve in San Lorenzo species diversity and abundance were very low compared to areas closer to camp (See *Fig. 2*). This could be attributed to the fact that the river and larger forest islands are a large distance away from the back of the reserve. For an animal to travel this distance would take hours with no water or shade before reaching more forest islands.

It is evident that there are differences in the species abundance and diversity of mammal species in an area of no cattle compared to an area with cattle. Despite there being a very obvious difference (*Fig. 12, 13, 14, 16 and 17*) there was no statistical back up (P-Value= 0.204-0.501) however, the study period was not long enough to gain enough data. Unlike African savannahs, Llanos de Mojos and the South American continent in general, contain no large grazing herd species such as the Wildebeest and have been for at least 50,000 years (Skarpe, S. 1992). This project looks at disturbance which in this case is the presence of cattle and if it should be removed it would allow a comeback of species as seen in San Lorenzo. Removing species such as Wildebeest from African savannahs would create an opposite type of disturbance as all species within this ecosystem have adapted to deal with high grazing pressures and thus removal would not only disturb the food web here but would fundamentally alter the environment and niches within it (McNaughton S.J. 1992). Since the 1950s the cattle industry has became one of the largest and most profitable industries (James D. N. & Daniel I. K. 1983). Intense cattle grazing therefore, is not a process at all natural in an area like the Beni. The consequences of such being that South American species are not pre adapted to the intense pressure applied to their habitats when cattle are present. Food webs are disrupted which decreases the species richness in the area. In Juvenna a higher level of flooding may occur due to trampling caused by the high number of cattle (Altesor, A. *Et al,* 2006). Height of grass is affected and so species such as Pampas Deer and Maned Wolf may be directly influenced. Due to the amount of damage inflicted on the ecology of the environment it will take years for any signs of regeneration to occur. San Lorenzo is an example of a regenerating ecosystem as it has been cattle free for around four years, this can be seen in the results section and the differences in species abundances and diversity. Grassland recovery may however take decades for plant succession to climax to a more natural state of dominant plants. A study by T.J. Valonea and P. Sauter (2005) found that it may take grasslands 20 years for signs of recovery to become apparent. Where cattle are present the land will contain different vegetation (changes in floral mosaic (Altesor, A. *Et al,* 2006)) which in turn will influence the species diversity of smaller mammals. San Lorenzo in this study has only had a few years of cattle removal which in the long term recovery scale is not very long however, species such as Pampas Deer (*Fig. 5*) and Capybara (*Fig. 12, 13, and 14)* are already found in higher numbers here in comparison to Juvenna as well as the first sighting of a Pampas Cat on the reserve. San Lorenzo is still recovering but overall already shows a much healthier ecosystem without cattle.

Fire Disturbance:

Post-fire Capybara sightings increased by over twenty (*Fig. 18*) in San Lorenzo. There was also an increase in the number of random encounters (*Fig. 26*). The fire almost reached the river in the north-westerly part of the reserve thus Capybara could have been forced to move to an area where transects were taking place, increasing the number of sightings obtained. The number of Capybara also showed an increase in Juvenna post fire (*Fig. 20*), an explanation of this increase being that under threat of the approaching fire, individuals swam across the river to reach safe, fire free ground. This is a common response of Capybara under threat and individuals were frequently observed jumping into the river when disturbed by the transect group (Frens, K. 2009).

Black Howler Monkey numbers did decrease after the fire although these numbers may be a false representation of the actual population within the reserve. In Juvenna and San Lorenzo there was a noted decrease in the number of individuals observed during transects (*Fig. 18 and 19*). Black Howler Monkey found in family groups of up to forty individuals (S.C. Silver *et al*, 1998). Each forest transect took place in the same forest islands in both study areas meaning that repeated counts of the same

individuals will create a false (inflated) impression of the population size. It is also difficult to count these animals at night as the only time they were spotted was when they became disturbed and if they could be located in torchlight. It was also impossible to distinguish individuals. Therefore due to these difficulties in counting these animals was done at the best of our abilities but numbers could be a false representative of the actual population (*Fig. 12*).

The number of Crab-eating Fox sightings increased post-fire (*Fig. 18 & 22)* and had the highest percentage abundance of species observed (*Fig. 24*) overall. Again more Individuals may have been pushed south from the river north of the reserve accounting for the higher number of sightings. The highest numbers of individuals spotted were in the river habitat (*Fig. 4*). The Crab-eating Fox is generally found in savannahs and forest habitats whilst. They are omnivores, consuming a variety of foods such as mammals, amphibians, crustaceans, insects, nuts (moteque nuts from own observations and fish. They will change their diet to suit what is available ie they are opportunistic feeders (Hover A. 2003).

Peccary overall increased in numbers after the fire and were observed more in the forest habitats (*Fig. 2*). This may be due to individuals or small groups being displaced from surrounding forest islands due to the fire to the forest islands in San Lorenzo. The need move would be for food or cover. However it is unclear whether the fire is to be blamed for the change in abundance due to lack of equipment making study in additional forest islands unfeasible.

A difference in the numbers of Giant Anteater showed that there were overall fewer individuals in San Lorenzo (*Fig. 19 & 22*) and an increase in individuals in Juvenna. There was an increase in the number of random encounters, possibly due to ground level grass allowing for making a sighting much easier (*Fig. 26*). Giant Anteaters are good swimmers (L.H. *et al,* 2004) which would allow them to swim over to Juvenna to escape any disturbance such as the fire. A sighting by one of my colleagues proved that Giant Anteater do in fact swim as it was noted an individual had swam from the Juvenna side to San Lorenzo. Thus this could be a reason why there are now more sightings of Giant Anteater (*Fig.23*). Sightings in the cerrado increased also, this could be attributed to the new ground level grass height as grass height so the chance of sighting an individual was greatly increased (*Fig. 19*). This potential movement of Giant Anteater is a sign that they have been displaced from their territories and the fire forced them to seek another (Juvenna). In order to flee fires the animal will flee into more cover such as forest islands or near the river (Silveira L. 1999).

One sighting of Puma occurred just hours before the fire reached that location precluding that the animal must have been fleeing the area. Three captures on camera traps were noted post fire in San Lorenzo (at least two separate Puma). Puma have large ranges (females ranging from 26-350km^2 and males ranging from 140-760km^2 (Shivaraju, A. 2003) and so to have at least two individuals within a very small area, compared to home ranges, would be very unlikely. This thus allows the assumption that these were individuals displaced by the fire. However, these Puma may be taking advantage of displaced prey items such as Peccary or other medium sized mammals displaced by the fire (*Fig. 14*).

Agouti showed the most change within San Lorenzo post-fire. This species was only documented on camera traps within one location (San Lorenzo, Forest Island) in which they were the most numerous species on the reserve pre-fire. However, after the fire numbers of Agouti were reduced to almost zero in the San Lorenzo area (*Fig. 23*). The reason for this could be that they have moved to another forest island to escape the fire.

Ocelot showed a reduction in numbers in both San Lorenzo and in Juvenna (*Fig. 24 and 25*) post-fire. This showed that there was a higher abundance in Juvenna but this was due to the low numbers of species in general that created a high percentage abundance per sample (12%). The reason for this could be that individuals have been displaced and are moving to a new territory or are moving to find/follow their prey. However, due to the numbers decreasing in Juvenna also it is hard to say that

the reduction in numbers in San Lorenzo is due to the fire. Further study would be required to understand the true population sizes and the possible movements of this animal.

The first recording of Pampas cat in the reserve (*Fig. 10 and 22*) is most likely due to the fire and the lack of grass in the savannah that would have otherwise obscured the images captured. However, this could be signs that San Lorenzo is recovering and thus allowing more species to return to the area. The Pampas cat may have been displaced from a area nearby due to the fire as well as cattle no longer being present, although the recovering habitat of San Lorenzo may harbour more prey items and thus has allowed this species to return. More studies must be completed to understand whether the removal of cattle is the cause of its return or if the cat has simply passed through the reserve to get to another location or escape the fire.

Ring Tailed Coati were only documented in San Lorenzo pre-fire (*Fig. 22*). Post-fire they disappeared and were then only spotted in Juvenna (*Fig. 23*). It may be that this species swam from San Lorenzo to Juvenna to escape the fire as they are good swimmers (Braddy, S. 2003). Further study is again required.

There is evidence of species being displaced from the affected side (San Lorenzo), an increase in several species in Juvenna which are able to swim (Giant Anteater and Ring Tailed Coati) and that there are species which are possibly moving into the reserve for the first time (Pampas Cat) or at least passing through (*Fig. 18-25*). This part of the study showed that there is a large difference in the abundance and diversity of species after a fire has passed through an area. It shows reduction in some species but an increase in others meaning that some may benefit directly because of the disturbance. It is possible that due to this disturbance a higher abundance of predators have moved to the San Lorenzo area due to the displaced prey. However, fires in any savannah habitat are a very natural occurrence and without it would be a disturbance in itself. The opposite of this, in South America, is that the presence of grazing animals such as cattle as there are no endemic large herd grazers, is not natural and therefore is a disturbance and thus removal would somewhat allow the land to regenerate to a more natural state (McNaughton S.J. 1992). Fires within San Lorenzo and Juvenna areas were man-made and were only used for the benefit of the cattle to rejuvenate the grass. They would not have been sustainable or properly controlled (example the fire which spread onto the reserve) and will have been destroying the land preventing true regeneration of the grasslands. As fire is a natural disturbance and without it the savannah would not be considered healthy, controlled man-made fires are set to create a more natural balance of species of mammals and grasses.

Fire is used for many purposes in this region (Llanos de Mojos) and it is all used for the benefit of the human race. It is the oldest form of technology used to change an ecosystem and is mostly used for clearing, management and transformation. Despite fire being a very natural phenomenon, man-made fires are the most uncontrolled and damaging problem the Llanos de Mojos faces (Erickson E.L. 2008). Species which are directly influenced by these wildfires may have adapted to survive or avoid such a disturbance but when humans are the cause, this is when species may become more affected. Species such as Giant Anteater are in great danger during fires as they are slow and sluggish but a study noticed that after this disturbance their numbers will increase (Silveira. L. 1999). However, species which dwell in the forest islands like Black Howler Monkeys and Capybara which are good swimmers will be less affected. The recovery rate of savannah habitats after fires may be 5 years however there is at present no conclusive research in this area. However, as long as rain continues to fall at a normal rate the grasses will re-grow at a normal rate (Skarpe, S. 1992).

Development of Project:

During the time before the expedition to Bolivia I decided to do a mammal project as no previous studies have done any in depth research into mammals in this area and the specific species and their abundance and diversity within the reserve. The only studies previously completed were to understand what species were found within the reserve. There was no work completed to find out whether cattle have had an influence on the mammal diversity in the reserve in the long term. As San Lorenzo had been cattle free for a few years the comparison was a great opportunity for study. I chose cattle disturbance as my main study as in South America there is no study involving its effect on large mammals such as Giant Anteater, Pampas Deer and Jaguar. Therefore it seemed intriguing to try to understand whether cattle in South American grasslands have an influence on mammal diversity and abundance. During the expedition a fire was started by a neighbouring ranch which completely changed the surrounding ecosystem and habitat structure. During this time I decided to focus my efforts in San Lorenzo to understand the immediate changes in the effects of fire upon species abundance and diversity affected. Juvenna was removed as a study site as there was now nothing to compare an area without cattle as even though San Lorenzo was still without cattle the area was so dramatically changed that no comparison was possible. Methods remained the as before the fire except Juvenna was removed as a study area and the project continued as normal. Therefore my project title changed to fit the extra disturbance that occurred, although data collection was now limited to just over three weeks per disturbance.

My methods were chosen to fit the behavioural patterns of the mammalian species studied. Night transects were chosen as they would allow a view of the nocturnal mammals (which was indeed most species). Camera traps were chosen as my main method for gathering data as they would provide constant data from nocturnal, diurnal and any moving animals in a very non-invasive manner. Scat and track transects were chosen to get an idea of what mammals are present in the reserve in case they were not encountered on camera traps or on transects. Day transects were chosen to make sure that all times during the day were covered so that there was a higher chance of an encounter. Random encounters were used as opportunistic sightings provided extra data to aid counts of species diversity.

Limitations of Project:

The biggest limitation of this project was data collection time due to the switch over of comparisons to concentrate on the fire disturbance in San Lorenzo. This was a forced change as the fire destroyed the comparison between cattle versus no cattle. This change meant that data collected for cattle disturbance was not valid anymore as habitats in each area were no longer fundamentally the same. It also meant that the fire disturbance was only studied for a short amount of time, not enough for data to be viable enough for statistical models.

It was difficult to understand the best methods for the project as there was only limited information available from online sources and from past expedition members. Methods were decided as fully effective after pilot studies were carried out upon arrival in the reserve. Due to the varied satellite signals there is a possibility that some GPS` were inaccurate or were contained malfunctions that prevented them from providing the correct reading during transects hence some `rouge` GPS points which have been excluded from maps. When using GPS` it was important to wait for a few seconds until the device had accurately located your location.

Camera traps were the most important piece of equipment for my project however, more would have been required to allow for proficient coverage of the reserve. If more areas were covered then more data would be collected creating a more viable statistical model and realistic view of species present. Another problem that was encountered using camera traps is that they are not fireproof. One Bushnell Trophy Cam 2012 Camera (HD) was lost on the cerrado path and despite this drawback there was one spare. A large problem with the camera traps was finding areas in which to place them. They required either a tree beside a defined path or in areas such as savannah and beside the river post had to be

cut to attach camera traps to. In the river habitat in San Lorenzo one camera trap fell over on multiple occasions and required constant maintenance.

Another limitation is my personal identifications of mammals, scat and tracks as I do not have experience in mammal surveys and identification of these species. It was difficult to identify species during night transects despite using strong LED torches and MAG lights. Thus each track and scat that was identified may not be correct or 100% accurate, due to possible high levels of inaccuracy these were not used in any of my statistical models or my results as they proved nothing compared to other methods used.

Standardised methods may not have been followed by some members of the team leading to possible incorrect sightings during transects being noted may lead to creating inaccurate data and a false representation within the results overall. During night transects sightings may have been missed due to the team talking and creating noise in general causing more disturbance and reducing the number of possible animal sightings.

Final Conclusions:

Through this study it can be said that both of the disturbances create a very profound difference and change to mammalian species abundance and species diversity. Each graph in the results section has shown that the number of species differs and their abundance can change depending on the disturbance experienced. It is also clear that more time is required to get a full understanding of these disturbances and the ensuing to the local ecosystems, which affect the entire food web and how these in turn affect the mammals studied. Time was the main limiting factor in this study although due to the fire there was no other option however, the fire proved an interesting and unique area for study. Looking at the results of this study, it can be seen that cattle have had a profound effect upon the species abundance and diversity although again, due to the fire this study was forced to a halt, thus statistical backup is very low due to the limited data able to be collected. Armonia are in the process of buying the Pelotal ranch east of San Lorenzo which will increase the area of the reserve by almost double. Once this land has been purchased, additional studies can be carried out to further understand the disturbance caused by cattle farming. Armonia has also secured the removal of cattle in Juvenna within a few years although it will take years of recovery before it could resemble San Lorenzo in both species diversity and abundance.

Fire disturbance had a very strong influence on the movements of large mammal species greatly affecting the previously seen abundances and diversities within both San Lorenzo and Juvenna. My results show that there is a very clear difference both before and after the fire whether increased sightings were due to displaced animals or were due to ground level grasses making spots easier, it is unclear. More studies should be completed as the amount of data gathered is very small and only covers a very short period therefore results may not be 100% representative of the entire population of study subjects.

The Barba Azul reserve is of great conservational importance as the species within are very diverse as well as critically threatened, as in the case of the Blue Throated Macaw. Important species such as Puma, Ocelot, Pampas Cat and Pampas Deer are all currently found within the reserve, a testament to the recovery of this area although full regeneration may still take many years. Further studies covering the entire region would provide a valuable picture of species abundances and diversity as well as giving a greater idea of how cattle disturbance has affected numbers on a larger scale. Further studies would also promote the area and hopefully open up avenues for further conservation and protection of the Beni ecosystem.

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Appendices

Camera Trap Locations: Time and date of placement and removal with GPS points (Decimal Degrees).

Camera Trap Location	**Dec.Deg. South**	**Dec. Deg. West**	**Camera 1**	**Camera 2**	**Time Set**	**Date Set**	**Time Down**	**Date Down**
Forest Island1(WH)	-12.245233	-65.888333	Cudde back	Bushnell	15:30:00	28 July 2012	15:30:00	04 September 2012
Forest Island 2(camp)	-12.251783	-65.898550	Cudde back	Bushnell	14:50:00	29 July 2012	10:40:00	04 September 2012
Savannah 1(WELL)	-43.213000	-65.893450	Cudde back	Bushnell	8:15:00	29 July 2012	Unknown	09 September 2012
Savannah 2(DI)	-43.200000	-65.878600	Cudde back	Bushnell	11:55:00	29 July 2012	09:00:00	04 September 2012
Cerado 1(camp)	-45.094000	-65.878650	Cudde back	Bushnell	17:45:00	29 July 2012	10:50:00	04 September 2012
Cerado 2(path)	-12.230467	-65.900050	Cudde back	Bushnell	15:36:00	30 July 2012	14:40:00	04 September 2012
River	-12.243517	-65.874650	Cudde back	Cudde back	14:40:00	02 August 2012	09:40:00	04 September 2012
Back 1	-12.306267	-65.878167	Cudde back	Bushnell	Unknown	01 August 2012	9:40:00	09 September 2012
Back 2	-12.306350	-65.862533	Cudde back	Bushnell	Unknown	18 August 2012	10:26:00	09 September 2012

Camera Trap Location	Dec.Deg. South	Dec. Deg. West	Camera 1	Camera 2	Time Set	Date Set	Time Down	Date Down
Cerrado	-12.239167	-65.880417	Cuddeback	Cuddeback	09:50:00	30 July 2012	09:14:00	04 September 2012
Forest	-12.229250	-65.907467	Cuddeback	Cuddeback	11:27:00	30 July 2012	15:00:00	06 September 2012
River	-12.250000	-6.044000	Cuddeback	Cuddeback	15:20:00	30 July 2012	08:02:00	04 September 2012
Savannah	-12.231283	-65.906300	Cuddeback	Cuddeback	09:00:00	30 July 2012	08:48:00	04 September 2012

5. Macaw report:

Foraging ecology, population monitoring and habitat use of the critically endangered blue throated macaw.

Figure 5.1: *Blue throated macaw (Ara glaucogularis) flying over at a point-count station (Photograph by Ryan Ward 2012)*

Written by Emily Macdonald

Introduction:

The Bolivian endemic species *Ara glaucogularis* (see figure 5.1) - common name blue-throated macaw, family psittacidae - is one of the most endangered macaw species in the world (Hesse 2000). The global population of the species is currently estimated at less than 200 individuals (Strem 2008; Yamashita and Machados de Barros, 1997). They inhabit the seasonally flooded savannahs of the Beni Department in the lowlands of north-western Bolivia, an area which is almost entirely unprotected. There are two subpopulations, the larger of which is located in an area to the north of the town of Trinidad and consists of around 160 birds, the smaller is located to the south east of this with only 25 individuals (Strem, 2008) (see figure 5.2). These two subpopulations are highly fragmented and are not thought to interact. Also, due to a range of pressures including cattle ranching, illegal trafficking and annual burning practices, the survival of the species is considered at great threat (Duffield and Hesse, 1997; Hesse 2000).

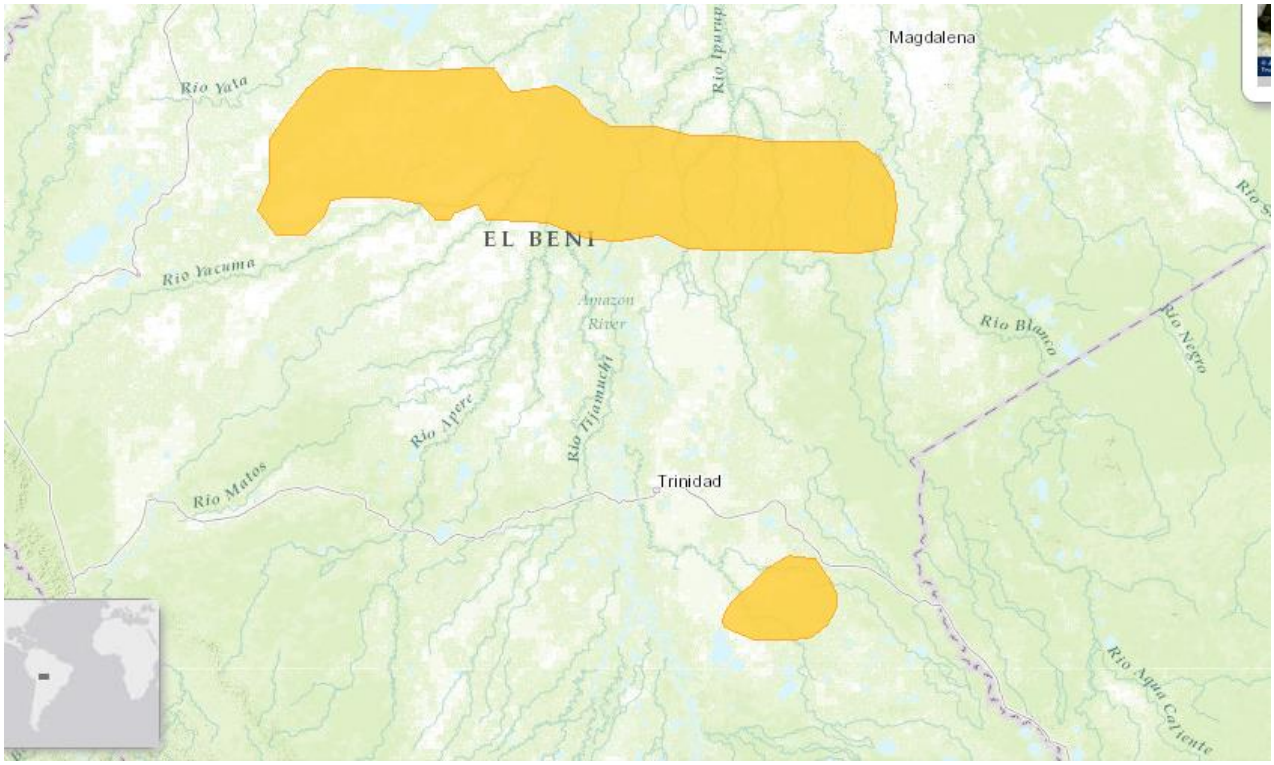

Figure 5.2: *Map of the distribution of the blue-throated macaw in Bolivia. The yellow areas define two different populations – the northern population thought to include around 160 individuals and the southern population thought to consist of only 25. (Map from IUCN 2013)*

Figure 5.3: *Plumage differences between the Blue-throated Macaw (left) and the Blue & Yellow Macaw (right). The difference in colour and size of the throat patch is distinctive as is the feather colour and pink skin of the blue-throated macaws face. (Photograph from Association Armonia).*

In contrast to the Blue-throated Macaw, the Blue and Yellow Macaw *Ara araruana* (see figure 5.3) has a very wide geographical distribution stretching across the South Americas (Parr and Juniper, 2010) and has the IUCN status of 'least concern'. The Blue and Yellow Macaw seems well able to exist in a substantially wider range of habitats than the Blue-throated Macaw, typically inhabiting seasonally flooded and gallery forests, rainforests, palm swamps and sometimes even deciduous forests a considerable distance away from any water source (Parr and Juniper, 2010).

On the Barba Azul Reserve both species utilise the forest islands of the grassland ecosystem, primarily feeding on fruits from the *Attalea phalerata* palm (motacu palm) which is endemic to this habitat and a keystone species which is integral to the existence of many species across the Beni savannahs (see figure 5.4).

Figure 5.4: *Two blue throated macaws (Ara glaucogularis) perched on the fruits of the Motacu Palm (Attalea phalerata) (photo by Dr Ross Macleod)*

Aims:

This study was conducted by the University Of Glasgow Bolivia Expedition team 2012 and extends both the monitoring programme implemented and conducted by expedition teams from Glasgow from 2009-2011 and also the foraging ecology studies first carried out in 2011. The main aim of this study was to achieve a greater understanding of the ecology of this little known critically endangered species with specific focus on foraging strategy. We aimed to investigate and find further proof of observed differences, recorded in 2011, in the approach of the blue-throated and blue and yellows to eating motacu fruit. Lastly, we aimed to continue our annual monitoring programme for the species by establishing the minimum population size of each species currently utilising the Reserva Barba Azul (RBA).

Methods

The study was split into two main sections: population estimation and macaw ecology. A small botanical survey was also carried out looking at the composition and the number of fruiting trees throughout Barba Azul Forest Island.

Population Estimation:

A minimum population study was conducted using multiple, simultaneous, stationary point counts at known pre-roost aggregation sites and fly-over sites around each of the three main forest islands in the reserve, Fortaleza (FO), Los Maneches (LM) and Barba Azul (BA) (see figure 5.5). Assessing all three islands at the same time would allow us to produce an estimation of the minimum population of both species currently utilising the reserve. The stationary points were carefully chosen during the 2011 study and were kept constant in 2012 to allow more accurate comparison of species number between the two years. The locations of these stations are indicated in figure 5.6.

Figure 5.5: *Satellite map showing the locations of the three forest islands under study within the reserve (Adapted from Google Earth maps).*

Particular stations were selected because they were sights where macaws were known to fly over or aggregate at dusk. We also chose sites that provided a good field of view of a large section of the forest island, and thus together allowed us to survey the vast majority of the islands perimeter and ensure that as few as possible macaws escaped our records. During the point counts observers recorded the following information about both blue-throated and blue and yellow macaw observations: the number of individuals, species, whether they left, arrived or flew over, the island of study and the point where the observer was recording. Time and the direction of flight were also noted to minimize the chance of the same bird being counted twice from two separate points. Any notable changes in weather on the day of recording were also recorded so that we could consider any effect this might have on bird numbers.

Figure 5.6: *Satellite map showing the stationary points used for the point count survey. The red dots show the location of the stationary points around the three main forest islands. Note that points 8 and 9 were not used in the point counts this year; they were only used in the individual island counts in the 2011 study which were not repeated in 2012. (Adapted from Google Earth maps).*

The study was carried out between 16:30 and 18:30 since the 2011 pilot study and previous observations by University of Glasgow Expeditions show that at this time the two macaw species gather and begin to leave the forest islands to roost in other areas both in and out of the reserve. If, as happened on some occasions, a significant number of birds were still seen to be leaving the island at 18:30 observers stayed for an extra ten minutes at the end of the study to ensure they recorded all birds leaving. The total point count survey was carried out four times, approximately once per week, during the expeditions six week field season on the reserve, giving a total of 28 individual point counts.

Before analysing the data it was important to avoid any double counting that might have occurred because birds flew over more than one set of field workers. In reality I could not be certain that no birds whatsoever would be double counted (or not counted at all) so a set of rules were developed to minimize any effects when the results were analysed. The majority of macaws from both species flew northwards over the reserve to roost out with its boundary, however a number did leave the reserve in other directions. From this information it was decided that only macaws flying over each station in certain directions, and those recorded leaving the forest islands, would be used to calculate the minimum population estimation. This meant that macaws flying over stationary points in the southern area of the reserve would not be counted again flying over stationary points north of these. For example, of all macaws recorded flying over point 4 only those flying in an east/north-east direction were included in the minimum population estimation as those flying in other directions would be included at other stationary points. The directions of flight of birds recorded flying over each stationary point, which were included in the minimum population estimation, are illustrated (see figure 5.7).

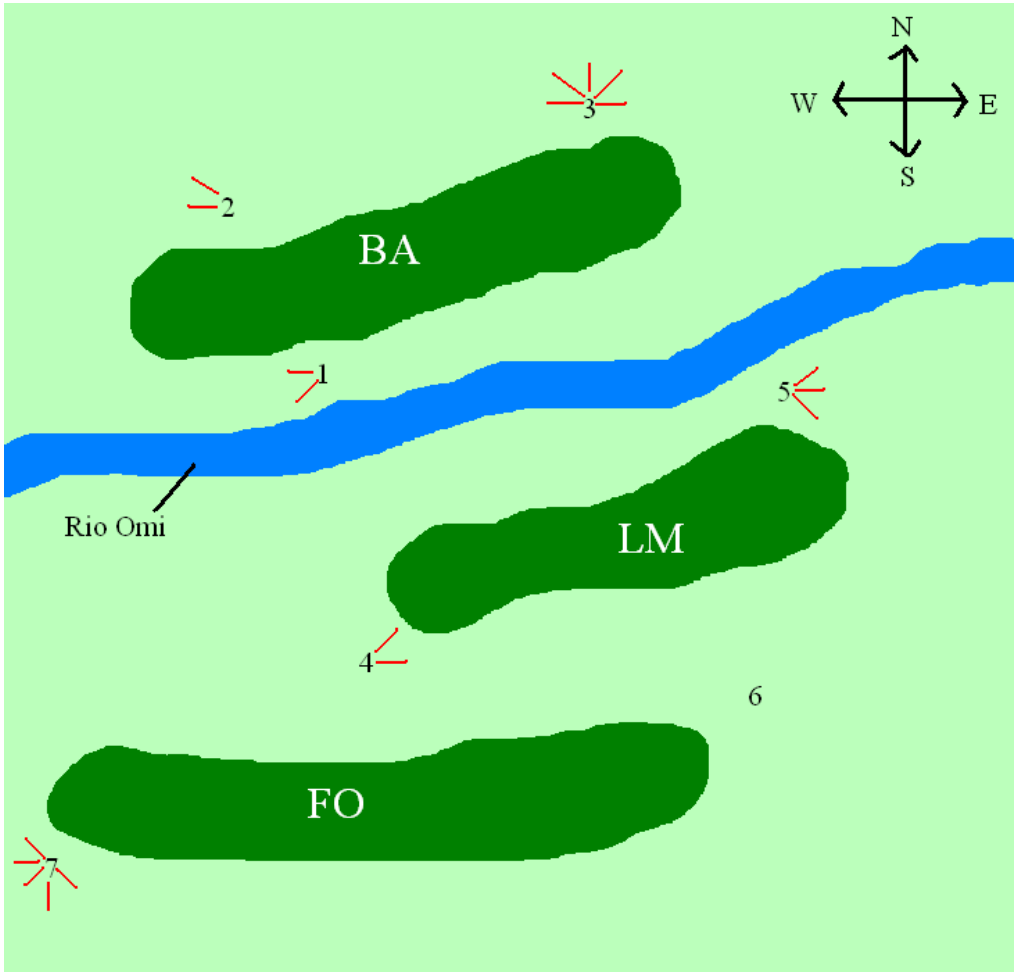

Figure 5.7: *The flight directions of macaws flying over which were used in the population size estimation at each stationary point. The red lines coming out of each observational point (numbers) show the direction of flight of those birds which flew over included in the study i.e. of those recorded flying over point 4 only those flying in an east/north-east direction were included in the minimum population estimation as those flying in other directions would be recorded at other stationary points.*

Ecology

The macaw ecology and foraging behaviour study was conducted throughout the Barba Azul forest island as this was where the majority of both macaw species were found in 2011. Field workers went out searching for macaws between 7:30-10.30 and 11:00-14:00 three days a week over five weeks giving a total of 24 study sessions. Once macaws were spotted and identified field workers spent time observing the birds and recording their behaviours.

The main aim of this study was to confirm that blue and yellow and blue-throated macaws consumed the flesh of *A. phalerata* fruits in different ways, holding the fruit in different positions and leaving species specific characteristic markings first described by Yamashita and Machos de Barros in 1997. This data was then used to determine whether or not these macaw species forage together.

Results:

Foraging Ecology

In 2011, it was noticed that each macaw species eat *A. phalerata* nuts in different ways however more visual observations of this were needed before any scientific conclusion could be drawn. Across 2011 and 2012 ten observations of Blue and Yellow and four observations of Blue-throated Macaws consuming these nuts were made, all of which showing the same result. The Blue and Yellow Macaw appear to eat by holding the nut at its base with one foot so that the nut was orientated vertically (upwards). It then put its whole beak over the top of the nut and scraped upwards. The Blue-throated Macaw held the nut at its base with one foot in a similar way to the Blue and Yellow Macaw but it rotated its foot so that the nut was orientated horizontally. It then used its beak to scrape the flesh from the nut horizontally whilst spinning the nut around with its foot (see figure 5.7). We were also able to capture an image of one blue-throated individual feeding on the fruits as described (see figure 5.8).

This appears to be how the species specific marks on the nuts are formed as described by Yamashita and Macho de Barros (1997). The marks of the Blue and Yellow Macaw go along the length of the nut, are reasonably smooth and are not engraved too deeply into the mesocarp. The marks created by the Blue-throated Macaw are deep and spin around the nut horizontally along its length (see figure 5.9 and 5.10).

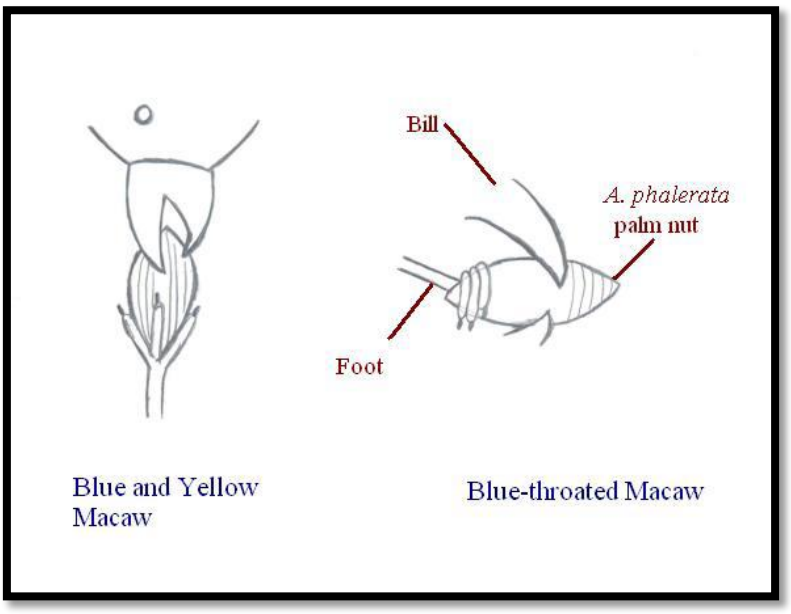

Figure 5.8: *Consumption of A. phalerata palm nuts by Blue and Yellow Macaws and Blue-throated Macaws.*

Figure 5.9: *The red circle indicates an individual blue-throated macaw within a foraging group eating an A. phalerata fruit as described by field workers. (Photograph by Emily MacDonald).*

Figure 5.10: *Characteristic marks on Attalea phalerata palm nuts. The characteristic banding pattern ('spin tracks') caused by the Blue-throated Macaw is seen on the left and the longitudinal markings caused by the Blue and Yellow Macaw in the middle. Primolius auricollis (Golden collared Macaw) leaves neither of these types of markings and forages on smaller palm nuts. (Photograph by Jo Kingsbury).*

It is important to note that less Blue and Yellow and Blue-Throated Macaws were seen during the foraging surveys compared to the study in 2011. It is likely that the reason for this is less *A. phalerata* fruiting in Barba Azul Island in 2012 compared to 2011. Currently the Botanical study is being analysed to confirm these findings.

This study also found that both macaw species tend to forage in similar areas throughout Barba Azul Island. These results, along with ecology mapping and minimum population estimates will be described and discussed in full in the final expedition report.

Population Estimation

From the total point count data the estimated population of the Blue-throated Macaw utilising the reserve was 38 birds and the minimum population of the Blue and Yellow Macaw was 321 birds (Table 5.1). The total number of Blue-throated Macaws on the reserve varied from 23 to 68 individuals and Blue and Yellow Macaws from 290 to 371 individuals on any one study day. As expected the frequency of Blue-throated Macaws was far lower than that of Blue and Yellow Macaws, as approximately ten times more Blue and Yellow Macaws used the Barba Azul Reserve than Blue-throated Macaws.

Point Count	Number of Blue-throated Macaws Recorded	Number of Blue and Yellow Macaws Recorded
1	68	371
2	34	313
3	23	290
4	27	310
Average Number Across the Study	**38**	**321**

Table 5.11: *The number of blue and yellow and blue throated macaws observed during each simultaneous point count study*

Discussion:

Foraging Ecology

There has so far been little investigation into the foraging behaviour, and other behaviours, of the Blue-throated Macaw but in this study it was noticed that the behaviours of both species were remarkably similar.

Across the studies in 2011 and 2012 Blue-throated Macaw was recorded eating the fruit of *Attalea phalerata* four times whereas Blue and Yellow Macaws were recorded a total of ten times, all in the species specific ways described in the results section. It is hypothesised that these methods are those consistently employed by each species in order to consume the palm nuts most efficiently. The species specific marks go some way in confirming this idea.

From observations during the foraging behaviour study it was noticed that both macaw species held *A. phalerata* palm nuts differently when eating them and consumed them in a different way (as described in the results section, Figure 5.8 and 5.9) leading to different characteristic marks in the fruit's mesocarp. It is hypothesised that this was due to the Blue-throated Macaw having a specialized modification of its beak which Blue and Yellow Macaws do not have. Blue-throated Macaws have a narrower chisel-like beak with a longer lower jaw than Blue and Yellows (Yamashita and Machado de Barros, 1997) which is perhaps used for better grip around the nuts breadth leading to these 'spin tracks' being scraped into the flesh. It is likely that this specialised beak is an adaptive trait which has

evolved for more efficient consumption of this particular palm nut since it is the primary food source of this species, whereas Blue and Yellow Macaws do not have this adaptation as they are more general foragers.

The two macaw species were not recorded eating any other plant materials other than the mesocarp of the *Attalea phalerata* palm nut. Other studies have recorded Blue-throated Macaws feeding on the seeds, fruits, flowers and stems of eight other plant species including *Acrocomia aculeata* and *Hura crepitans*, however they agree that the motacu palm fruit is the most important and abundant constituent of their diet (Yamashita and Machado de Barros, 1997; Hesse, 2000). One foraging observation which was not witnessed during this study is described by Jordan and Munn (1992). Blue-throated Macaws were recorded occasionally opening up the fruits of immature *Attalea phalerata* palms and drinking the liquids within them. One source suggests that the reason they may consume unripe nuts is to gain a 'competitive edge' over mammals which disperse the fruits over a wide area (Hoyo *et al*. 1997). Perhaps this behaviour was not witnessed in this study as palm nuts were plentiful and competition with mammals was low in the area allowing Blue-throated Macaws to consume only ripe nuts. On the other hand it is possible that this behaviour is just exceptionally rare and if this study was expanded we may have recorded this behaviour.

Population Estimation

A minimum number of 38 Blue-throated Macaws and 321 Blue and Yellow Macaws were recorded utilising the Barba Azul Reserve during this study. For the Blue-throated Macaw this number is almost significantly less than the number recorded by The University of Glasgow Bolivia Expedition (2011) in the previous year (n=52). In the 2010 study by the expedition an 103 birds were recorded. It is possible that the large number recorded in 2010 was a fluke or a miscount during the data recording. However this seems unlikely as three times (over 12 point counts) during the study more than 70 Blue-throated Macaws were recorded leaving or flying over BA island alone (University of Glasgow Bolivia Expedition Report, 2010). A more plausible explanation for this is that a large number of Blue-throated Macaws which were recorded on the reserve previously are now utilising a different foraging ground (perhaps one which is closer to their roosting site or has less competition from Blue and Yellow Macaws) or that the number of Blue-throated Macaws in the area has dramatically decreased over that last year. Without further study in the areas surrounding the Barba Azul Reserve the reason for this decline will remain unknown.

In the previous year the University of Glasgow Bolivia Expedition calculated the minimum number of Blue-throated Macaws on the reserve to be 398, slightly more than the number recorded in this study (n=321). There are a number of factors which could have contributed do this decline. Perhaps the savannah fire forced individuals to search further afield for foraging grounds.

When leaving the forest islands to roost at sundown the vast majority of the two species flew off in a northerly direction (N, NE, NW) which agrees with the results obtained in the 2011 and 2010 expeditions. This indicates the likely direction of the roost sites of the Blue-throated and Blue and Yellow Macaws using the reserve. A proportion of Blue and Yellow Macaws are known to roost in several of the smaller islands in the north of the reserve but little is known about where exactly these Blue-throated individuals roost, except that it is not believed to be within the reserves boundary (Mauricio Herrera, personal comment).

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6. Grassland Passerine Report:

Monitoring species abundance & distribution

Figure 6.1: *The cock-tailed tyrant (Alectrurus tricolor) – a species classified as near threatened on the IUCN redlist and which has been recorded on the reserve annually since 2009. (Photograph by Jo Kingsbury)*

Written by Jo Kingsbury

Introduction:

Figure 6.2: *Adult male black-masked finch (Coryphaspiza melanotis), caught in savannah mist nets during a 2010 survey. (Photo by Jo Kingsbury)*

Altogether, five hundred and nine bird species have been recorded across the Beni Savannah ecosystem (Beck & Moraes 1997). In 2009, diversity inventories conducted by Glasgow University (GU) within the protected boundaries of the Beni's, Reserva Barba Azul (RBA), highlighted its importance for several of the regions vulnerable and near threatened species. In addition to important populations of critically endangered blue throated macaws, the reserves open grassland habitats were found to hold several designated birds. Globally threatened grassland species recorded on the reserve that year included: the cock-tailed tyrant (*Alectrurus tricolor*) (see figure 6.1), black-masked finch (*Coryphaspiza melanotis*) (see figure 6.2) sharp-tailed tyrant (*Culicivora caudacuta*) (see figure 6.3), and greater rhea (*Rhea americana*) (Herrera & Mailard 2007; Reekie 2010).

Figure 6.3: *Adult sharp-tailed grass-tyrant* (*Culicivora caudacuta*) *(photo by Steven McGee Calender)*

Figure 6.4: *Adult wedge-tailed grass finch (Emberizoides herbicola), (photo by Jo Kingsbury)*

In 2010, a network of permanent transects were set up across the reserves grasslands and a new monitoring scheme implemented, targeting four of these species. These surveys yielded baseline abundance estimates for the reserves populations of cock-tailed tyrant, black-masked finch, sharp-tailed tyrant and, more common, wedge-tailed grass finch (*Emberizoides herbicola)* (see figure 6.4) – the latter, not currently threatened, but an important indicator species for healthy grassland ecosystems (Stotz et al 1996). In addition, patterns of distribution and microhabitat preferences were investigated for each target species to inform reserve management plans. In 2011, surveys were repeated and extended.

In 2012, we aimed to continue monitoring target species and start mapping their distributions and habitat use.

Original Aims:

Our objectives in 2012 were to continue monitoring populations of target survey species via line transects and distance sampling methods. We also aimed to map the density and distribution of each species in relation to habitat choice across the grassland area of the reserve.

Figure 6.5: *A view north from the banks of the River Omi in RBA south showing the glow coming from the fire as it rages in the savannah on the far side of RBA north's main forest island (silhouetted). (Photo by Marco Antonio Senzano Castro)*

Alterations to original aims and justification:

On the afternoon of August the 11th 2012, a fire originating on a neighbouring ranch passed across the north-west boundary of the reserve. The owners had been conducting burning on their land to stimulate new pasture growth for grazing cattle, when their fire became out of control. By that evening the fire had spread significantly across the reserve (See figure 6.5), reaching the more southerly grassland near camp the following morning. In subsequent days, we investigated the extent of the fire. It soon became clear that over half of the reserves grassland habitat had been removed by the burn and that a significant proportion of the set transects were affected. Indeed, only one transect remained entirely untouched and of the others, only three had small sections of grass anywhere along their length. The scene was devastating. The once lush, bio-diverse grassland was turned into a charred field (see figure 6.6).

Figure 6.6: *A view north across the savannah from the main forest island showing the extent of the burnt area. The pathway at the centre of the picture is part of a fire-break cut in early 2012 (photo by Jo Kingsbury)*

Consequently we were forced to alter the project - using pre-fire data only to produce abundance and density estimates for target species

Methods:

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 how estimations of target species abundance and distribution were assessed in 2010 & 2011 and also because 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.

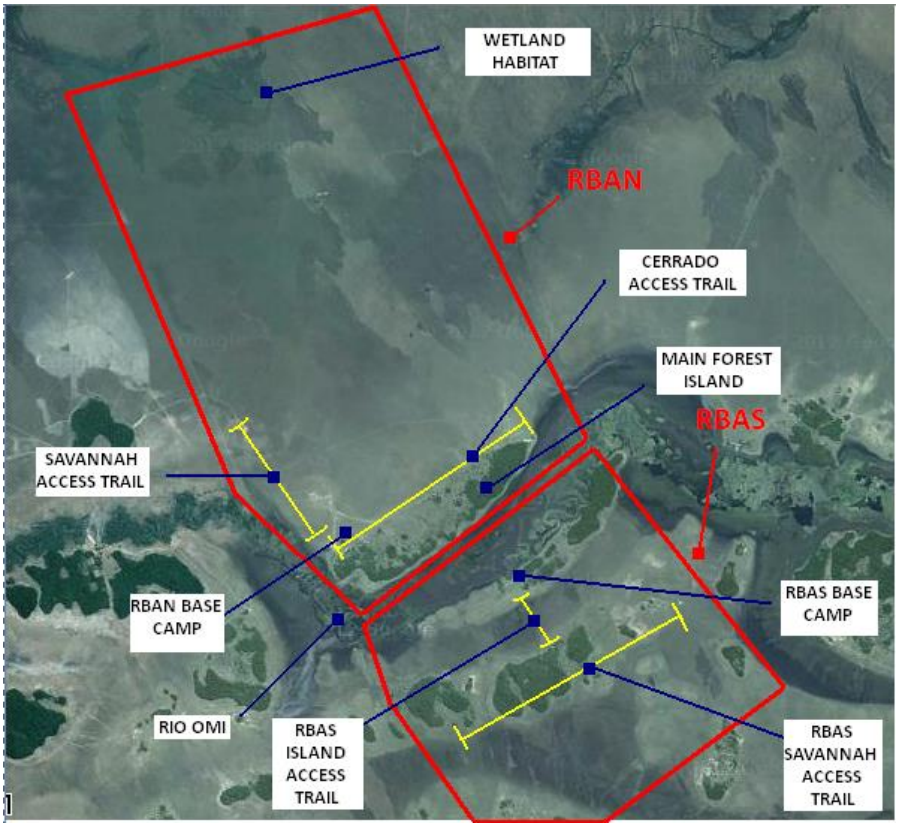

Figure 6.7: *Satellite map of the Reserva Barba Azul showing Reserva Barba Azul North (BBAN) and Reserva Barba Azul South (RBAS). Reserve boundary shown in red, Access trails in yellow and habitat features in blue. (adapted from Google Maps(2012))*

The transect networks used in Reserve Barba Azul North (RBAN) for baseline abundance and distribution surveys in 2010 and those extended across Reserva Barba Azul South (RBAS) in 2011 were re-used. Transects had been marked out during these prior surveys using a systematic approach, as recommended by Bibby *et al.* (2000), with a fixed distance of at least 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 four sets: the first consisted of sixteen transects (T00–T15) crossing the savannah on a bearing of N20ºW 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 6.7); the second consisted of 5 transects (SF1-SF5) commencing into the savannah at a bearing of S60ºE (i.e. perpendicular to those in the first set) from a small, open savannah access trail running from base camp toward the northern limit of the reserve (See Figure 4.7); the third consisted of one isolated transect in RBAN, laid out at the most northern end of the reserve (FF1);

Conducting line transects: Transects were conducted six days a week. The order of survey was drawn at random and it was intended that all transects would be walked once over the 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.

Since the birds were most active between the hours of dawn and mid-morning (Personal Obs), 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 6.8). 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.

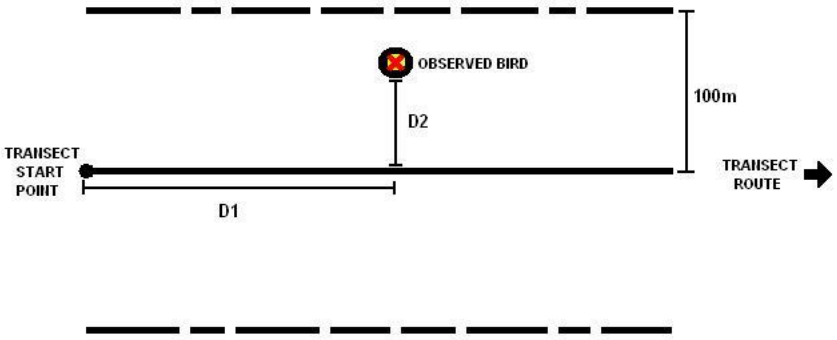

Figure 6.8: *Diagram outlining method used to collect bird position data. D1 represents the distance "along" the transect; D2 represents the distance "from" the transect. Adapted from image in Bibby et al.(2000).*

Identification and sexing of species was assisted, where necessary, with field guides including colour 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 mapped in 2010 surveys (Kingsbury 2010).

Data Analysis:

Distance 6.0 software (Thomas et al 2010) was used to produce density and abundance estimates for each survey species. Estimates were stratified by grassland habitat and compared with estimates produced from 2010 & 2011 expeditions in order to monitor any changes in the populations of target species.

Results

2012 Results Summary Table:

	Habitat	Obs	De/Ha	Density 95% CI	SE	HAAE	Abundance 95% CI	SE
Cock-tailed tyrant	CSS	0	0.000	0	0	0	0	0
	CL/SF	2	0.022	0.003 - 0.148	0.021	46	7 - 311	44.995
	CS/CC	0	0.000	0	0	0	0	0
	WET	0	0.000	0	0	0	0	0
Black-masked finch	CSS	3	0.701	0.391- 1.254	0.197	53	30-95	14.911
	CL/SF	4	0.155	0.039 - 0.616	0.108	326	82 - 1293	226.76
	CS/CC	12	0.397	0.138 - 1.145	0.206	129	45-373	67.024
	WET	0	0.000	0	0	0	0	0
Wedge-tailed grass finch	CSS	2	0.345	0.259 - 0.457	0.048	26	20 - 35	3.615
	CL/SF	9	0.423	0.198 -0.903	0.156	888	416 - 1896	327.2
	CS/CC	16	0.571	0.312 - 1.047	0.165	186	102 - 341	53.588
	WET	3	0.320	0.219 - 0.467	0.054	86	59 - 126	14.421

Figure 6.9: *Summary Results - 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.*

Species density and abundance data from the Distance assessment outputs has been summarised in Figure 6.9.

Abundance Estimation

Total Population Estimation for Reserva Barba Azul North (RBAN): Total estimated abundance for RBAN was 508 black-masked finch (BMF); 1186 wedge-tailed grass finch (WTGF) and 46 cock-tailed tyrant (CTT) (see figure 6.10 & 6.11). BMF populations seem to have increased since 2011, but overall, but populations have declined by around 33% since the 2010 baseline. WTGF populations have also dipped then increased over the same period, however in this case overall population size has actually increased overall by 58% between 2010-2012. CTT populations have steadily declined each year. Rate of decline was sharper between 2010-2011 (76%) than 2011-2012 (55%) with an overall reduction of almost 89% of since 2010 estimations.

	Estimated Population (RBAN)		
SPECIES	**2010**	**2011**	**2012**
Cock-tailed tyrant	427	103	46
Black-masked finch	768	318	508
Wedge tailed gras-finch	750	491	1186

Figure 6.10: *Total population estimates for Reserva Barba Azul North (RBAN) for each target survey species. Year on year figures indicated.*

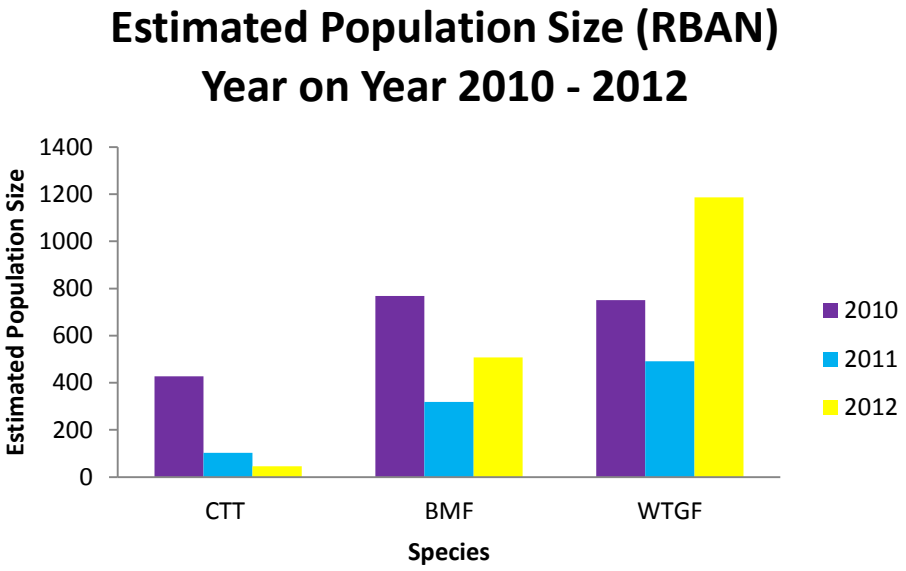

Figure 6.11: *Graph depicting the total population estimates for Reserva Barba Azul North (RBAN) for each target survey species. Year on year figures indicated.*

Distribution Assessment

Cock-tailed tyrant for Reserva Barba Azul North (RBAN): CTT still exhibit habitat specialism, only occurring in the campo limpo/seasonally flooded (CL/SF) grasslands (see figure 6.12). However this was the first year since 2010 that they were not observed in the reserves wetland grassland. Density in the CL/SF grasslands has continued to decline each year from 0.189/ha – 0.041/ha (-78%) between 2010 – 2011 and 0.041/ha – 0.022/ha (-46%) between 2011 – 2012 – an overall decline in density of -88%.

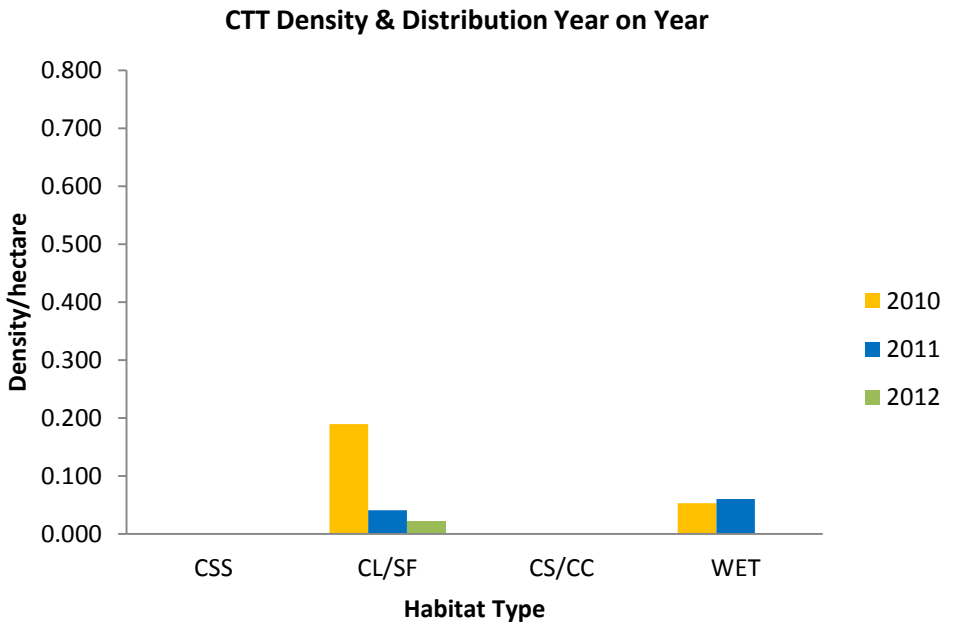

Figure 6.12: *Graph depicting the estimated, year on year density/ha for the Cock-tailed tyrant (CTT) separated by habitat.*

Black-masked finch for Reserva Barba Azul North (RBAN): BMF were observed in most habitats again this year (see figure 6.13). However, like CTT, this was the first year since 2010 that they were not observed in the reserves wetland grassland. BMF density has was considerably higher in 2012 in CSS 0.226/h – 0.701/h (+210%) and CS/CC 0.258/h – 0.379/h (+47%) c.f. 2011 after remaining fairly stable between 2010 – 2011. BMF density increased marginally in 2012 in CL/SF c.f. 2011, however, overall this habitat has had the most pronounced declines for this species between 2010 – 2012 0.3/ha – 0.155/ha (-48%).

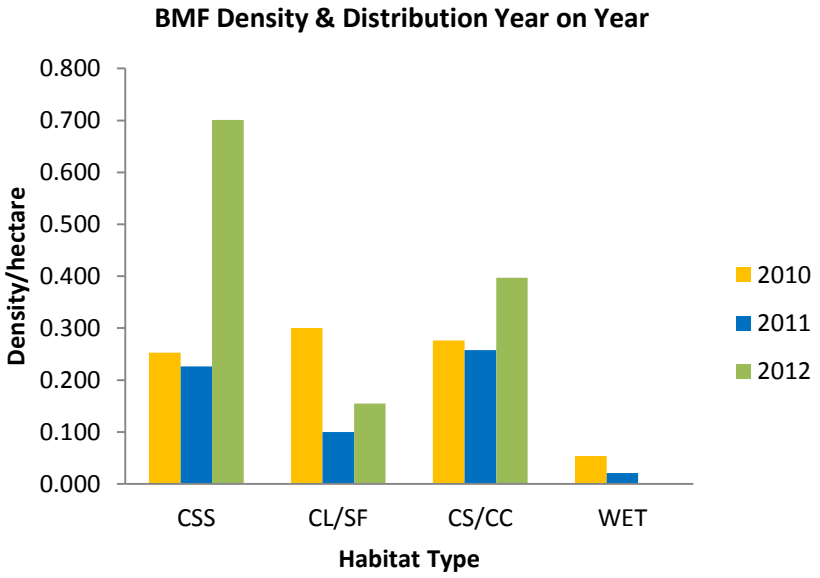

Figure 6.13: *Graph depicting the estimated, year on year density/ha for the Black-masked finch (BMF) separated by habitat*

Wedge-tailed grass-finch (WTGF) for Reserva Barba Azul North (RBAN): As in previous years, WTGF were observed in all the habitats surveyed (see figure 6.14). They have increased in density in each of these habitats since 2010 despite some declines between 2010 – 2011 – most pronounced in the CL/SF habitat 0.292 – 0.169 (-42%). Between 2010 – 2012, density has increased in: CSS by 0.319 – 0.345 (+8%); CL/CF by 0.292 – 0.423 (+44%);CS/CC 0.279 – 0.571 by (+105%) & WET by 0.041 – 0.320 (+680%).

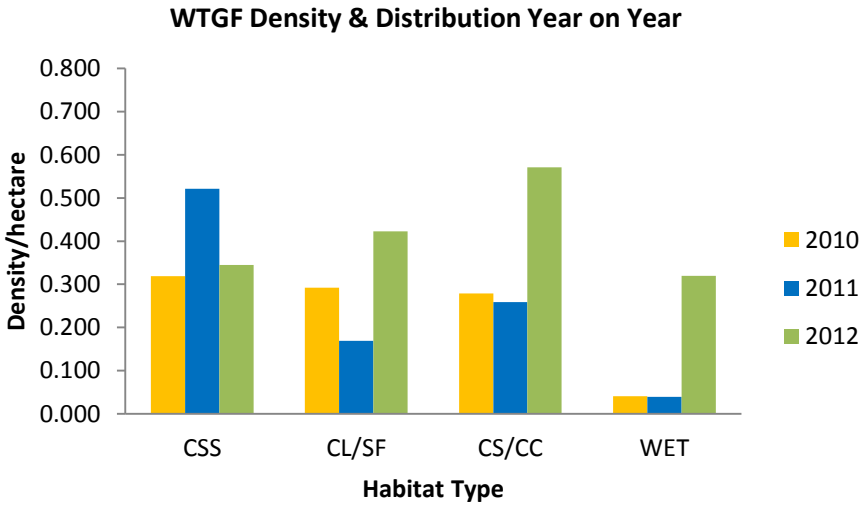

Figure 6.14: *Graph depicting the estimated, year on year density/ha for the Wedge-tailed Grass Finch (WTGF) separated by habitat*

Discussion:

Overall abundance of BMF and WTGF have rebounded this year following some fairly sharp declines noted between 2010 and 2011. In particular, WTGF population estimates are the highest we have recorded for the reserve. Despite an increase this year, BMF have failed to met or surpass the high estimates achieved in 2010, but populations are still healthier than those estimated in 2011. Sadly, CTT populations have declined further this year following the trend observed between 2010 – 2011.

With respect to the large declines seen in CTT populations again this year and considering the specialist nature of this species in habitat selection (See Kingsbury 2010 for more detail) it may be that this species is specifically sensitive to some kind of change within the CL/SF grassland. Prior to this years study and the study conducted in 2011, accidental grassland fires occurred - passed over from out of control burns taking place on neighbouring ranches. However, prior to the 2010 study there had not been a reserve fire for two years. The later successive stage of the grassland in 2010 could therefore be integral to the CTTs ecology and essential for supporting the high species densities observed that year. If this is the case, it could be likely that the August 2012 fire will have further impact on the abundance of the species on the reserve.

Finally, the greatest species density declines have been observed for the two more threatened species, the BMF & WTGF, within the CL/SF grassland over the 3 year period. As such, this might suggest the fragility and importance of this habitat for maintaining large populations of these birds on the reserve in the long term. If burn management were to be implemented, a key recommendation would therefore be to protect large stands of this habitat, burning these rotationally over longer periods of >2 years.

It is recommended that monitoring of these species continues in the future and that fire frequency is considered in the analysis of future study.

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7. Herpetology Report:

Species diversity and the impacts of habitat disturbance

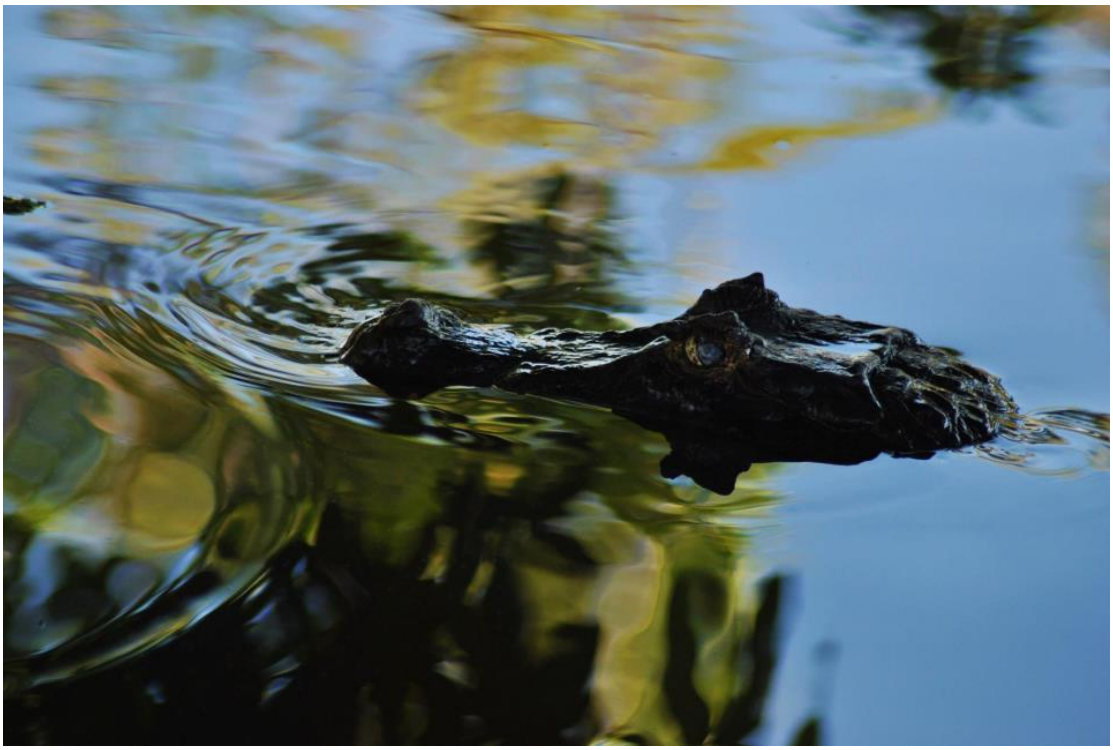

Figure 7.1: *Spectacled caimen (Photograph by Ryan Ward 2012)*

Written by Katie Thomson

Introduction:

The herpetology fieldwork was undertaken in the first three weeks of the expedition. The study was led by herpetologist, Marco Antonio Senzano Castro and his assistant, Marco Aurelio Pinto Viveros (see figure 7.2) - both students from the Universidad Autonoma Gabriel Rene Moreno in Santa Cruz De la Sierra. The University of Glasgow expedition team also assisted with the fieldwork.

Figure 7.2: *Our herpetologist Marco Antonio Senzano Castro (right) and his assistant, Marco Aurelio Pinto Viveros (left). Nb. this photo was* ***not*** *taken on the reserve and no anacondas were encountered during our survey.*

Aims:

The aim of the project was to survey the diversity of reptile and amphibian species within the Reserve Barba Azul and investigate differences in diversity between ranched and un-ranched land.

Methods:

There were 3 main parts to the study: morning and afternoon visual encounter searches (VES), night transects and pit trap surveys.

Morning & Afternoon VES: Morning and afternoon VES took place six days a week, for three weeks. Time was split equally between two sections of the Reserva Barba Azul (RBA) so that every week, three morning and afternoon VES were conducted in the Reserva Bara Azul North (RBAN) and three in the Reserva Barba Azul South. RBAN has been cleared of cattle and protected for 4 years while RBAS was still being used to range cattle at the time of survey. These two sections of the reserve are divided by a natural barrier, the Rio Omi.

Searches lasted around three hours and were rotated between three survey habitats - river, forest and cerrado - on a weekly basis. During searches, observers walked slowly and searched the ground, surrounding vegetation and underneath fallen logs for amphibians and reptiles. Any species encountered was identified in the field using appropriate keys and texts and recorded along with any observation of its activity or behaviour, a good description of the habitat it was found in and a GPS point.

Night Transects: The night transects consisted of three 100m routes per evening. These again took place six days a week in both RBAN and RBAS. They focused primarily on trying to locate amphibians and snakes and were only conducted in the riverbank habitats. Each transects was selected and marked out using a GPS, during the day. A transect took approximately an hour to complete depending on the abundance of the species. Each was repeated at least twice over the three week survey. Bright torches were used to carefully search along the transect line and up to a meter either side. Frog calls were also used to locate individuals. When an individual was encountered, it would be carefully caught and identified, its weight would then be taken using an electronic balance (see figure 7.3). Some measurements were also taken including; snout to vent and width of head. Photographs were taken of each specimen for reference. During this part of the study it was made clear to the students involved not to use any insect repellents or creams that would be toxic to the frogs.

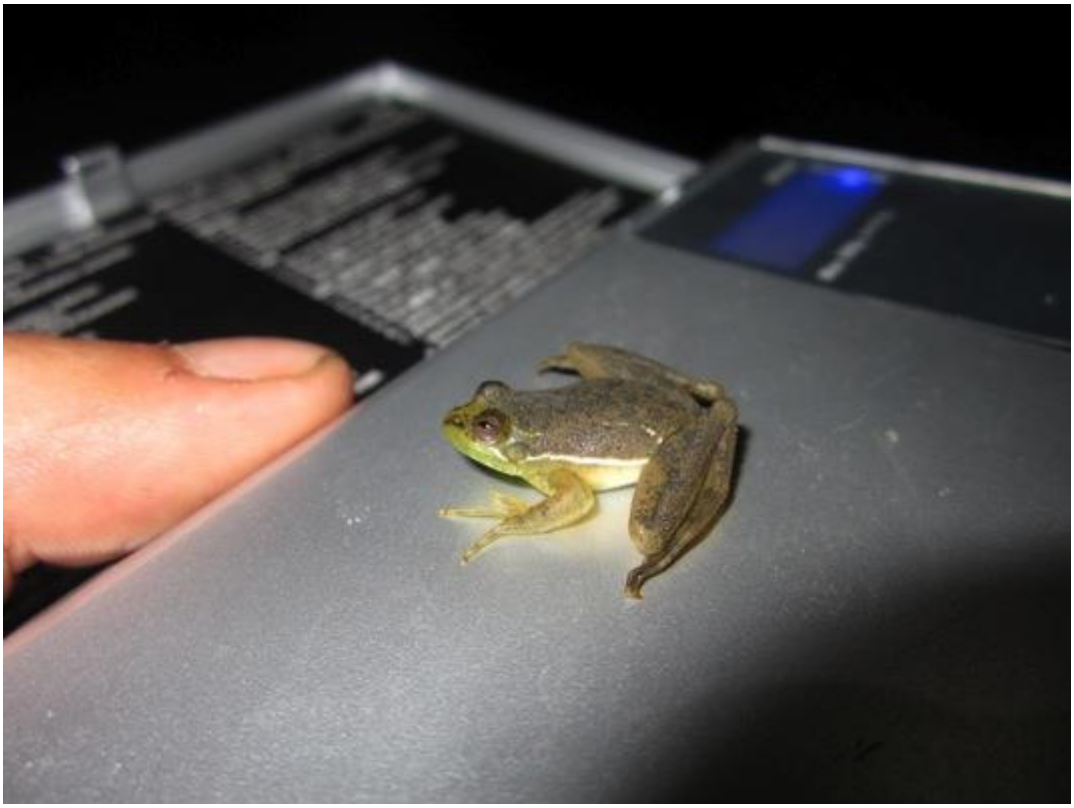

Figure 7.3: *Amphibian species found during a night transect - being weighed on the electronic pesola*

Pitfall Traps: These were set up in RBAN but not in RBAS and thus records from these will only be used in the diversity survey and not the habitat disturbance survey. In RBAN, they were located in forest edge habitat, very near to the river. Putting traps inside the forest helped to ensure that any animals trapped during the day were less likely to over-heat and dry out. These were also checked regularly every morning at 8am, afternoon at 1pm and in the evening at 6pm, through-out the three week study.

The traps were used to increase our chance of recording lizard and snake species. The set up and general-lay out of the traps is illustrated (see figure 7.4). Holes were excavated at a central point and at three points, equally spaced and located 5m from the central hole. Domestic cleaning buckets were placed in these holes and we ensured that the lip of each bucket was smoothly aligned with the ground. Sheets of tarpaulin were used to create drift fences to direct specimens into the buckets. Tarpaulin sheets were dug into the ground and supported with canes to make the drift fence sturdier (see figure 7.5).

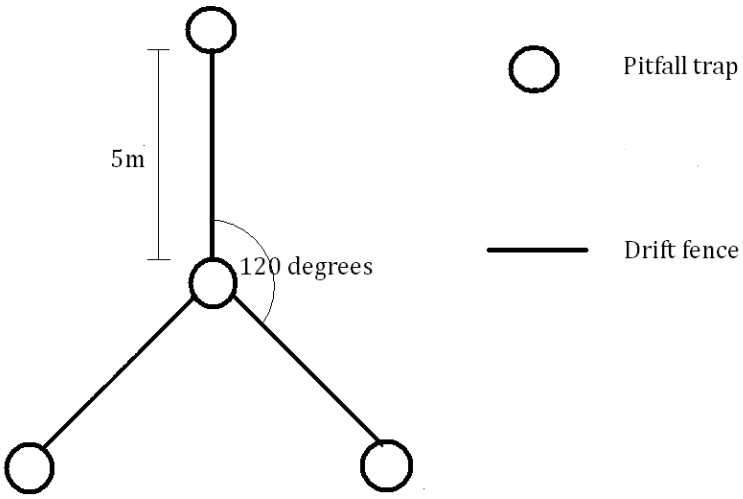

Figure 7.4: *Aerial diagram of pitfall trap array*

Figure 7.5: *Photo of the set up of the of the pitfall traps in the forest beside the riverbank.*

Any amphibians or reptiles found during a trap check were identified and quickly released. The same data as that taken for individuals found on night transects was also recorded for each species where possible.

Results & Discussion:

Searches proved to be successful with 14 amphibian species and 16 reptile species caught and identified (figures 7.6 and 7.7). Often we also found tadpoles (figure 7.8). However, the diversity of species was not as high as we had expected to see. This could have been due to our timing, as the dry season was well underway during our visit. Additionally, we had some notably cool days over the survey period that may have affected the numbers of both amphibians and basking reptiles seen.

Family	**Genus**	**Spcecies**
Teiidae	Ameiva	ameiva
Alligatoridae	Caiman	yacare
Alligatoridae	Melanosuchus	niger
Gekkonidae	Hemidactylus	mabouia
Iguanidae	Iguana	Iguana
Viperidae	Bothrops	mattogrossensis
Colubridae	Liophis	poecylogirus
Colubridae	Leptpdeira	annulata
Colubridae	Helicops	leopardinus
Colubridae	Chironius	exoletus
Gymnophtalmidae	Mabuya	guaporicola
Chelidae	Phrynopus	geofroanus
Gymnophtalmidae	Cercosaura	ocelata
Gymnophtalmidae	Cercosaura	eigenmani
Colubridae	Liophis	almadensis
Teiidae	Tupinambis	sp

Figure 7.6: Shows the Reptile species found on the RBA

Family	Genus	Species
Hylidae	Hypsiboas	raniceps
Hylidae	Lysapsus	limellus
Leiuperidae	Physalaemus	albonotatus
Hylidae	Hypsiboas	punctatus
Hylidae	Dendropsophus	nanus
Bufonidae	Rhinella	schneideri
Leptodactylidae	Leptodactylus	fuscus
Leptodactylidae	Leptodactylus	podicipinus
Bufonidae	Rhinella	major
Hylidae	Scinax	ruber
Leptodactylidae	Leptodactylus	dyptix
Leptodactylidae	Leptodactylus	chaquensis-macrosternum
Leiuperidae	Pseudopaludicola	boliviana
Leiuperidae	Physalaemus	centralis

Figure 7.7: Shows the Amphibian species recorded on the RBA

Figure 7.8: *A large tadpole found in the Rio Omi during an afternoon VES*

Night transects seemed the most successful with many amphibian species encountered and recorded. These included the polkadot tree frog (hypsiboas punctata) (see figure 7.9) and this large leptodactylid (see figure 7.10).

These night transect proved sometimes to be very difficult as there were a great deal of mosquitos and flies at the riverbank areas and biting was inevitable without insect repellent on, making it very demanding to keep full concentration.

Figure 7.9: *A polka-dot tree-frog found on vegetation along the Rio Omi during our night transects.*

Figure 7.10: *A large leptodactylid found on the riverbanks of the Rio Omi during our night transects.*

The pitfalls did not catch as many lizards or snakes as hoped, perhaps again the time of year could have something to do with this. They did however catch frog species that were not encountered along the river. The pitfalls set up in the forest beside the river proved to be considerably more successful those in the forest beside the savannah.

Unfortunately the herpetology report not yet finalised. The data is currently being analysed by our Bolivian counterparts. This will be forwarded by April 2014.

8. Raptor Report:

Abundance, diversity & distribution of raptors across the habitats of a seasonally flooded Bolivian Savannah Ecosystem

Figure 8.1: *Juvenile great black hawk (Buteogallus urubitinga) – (Photo by Jo Kingsbury)*

by Andrew McCondichie

Introduction:

2012 was the very first year that focused raptor surveys had ever been conducted on the Reserva Barba Azul (RBA) by Glasgow University expedition teams. We hope that more intensive focused surveys will help to explore the diversity and habitat use of raptors in more detail and bring to light more information on the ecology of raptor species found within the reserve. Currently raptors are understudied as a group in the South Americas; this study hopes to help in some way to change this.

Aims:

This project aimed to survey raptor diversity within the RBA and explore differences in habitat use between species. Habitats surveyed included: savannah, cerrado, forest edge and river. It also aimed to investigate differences in raptor species assemblages across these habitats between grazed land, being used to range cattle at the time of study and protected land, where cattle have been removed for four years and major habitat regeneration has taken place as a result.

Alterations to original aims and justification:

Due to a fire occurring on the grasslands of Reserva Barba Azul North (RBAN) the aims of the study had to be somewhat modified. The new aims were to survey and map differences in pre and post-fire raptor diversity and distribution.

Original methods:

Point counts were used to survey raptor diversity and abundance. Each week, point counts were conducted at 5 points along a set transect in each survey habitat (forest edge, river, savannah and cerrado) and in each section of the reserve (undisturbed RBAN and disturbed Reserva Barba Azul South (RBAS)). These were conducted in both the morning and evening so that a total of 16 point transects were conducted each week – giving a total of 80 individual point counts per week.

Each transect extended 2km with points at 500m intervals. 20mins was spent conducting a count at each point to observe what species where present. Binoculars and a scope were used to search for raptors. On observing a raptor, species, sex, no of individuals and estimated distance to the bird was recorded. Where possible a photo was taken and any notes on plumage recorded. We also recorded the activity of the individual (flying/perched/ground) along with their distance from the ground.

Opportunistic species records were also recorded throughout our time in the field, as were any other observations deemed important such as nest locations.

Alterations to original methods:

Following the fire, we dropped transects in RBAS and focused on surveying post-fire raptor abundance and distribution in RBAN. We added two new transects: one which followed a section of savannah with burnt grassland on one side and the un-burnt grassland on the other (sav edge), the other which passed directly through the worst effected burnt grassland (burnt). These have been illustrated alongside the other transects below (see figure 8.2).

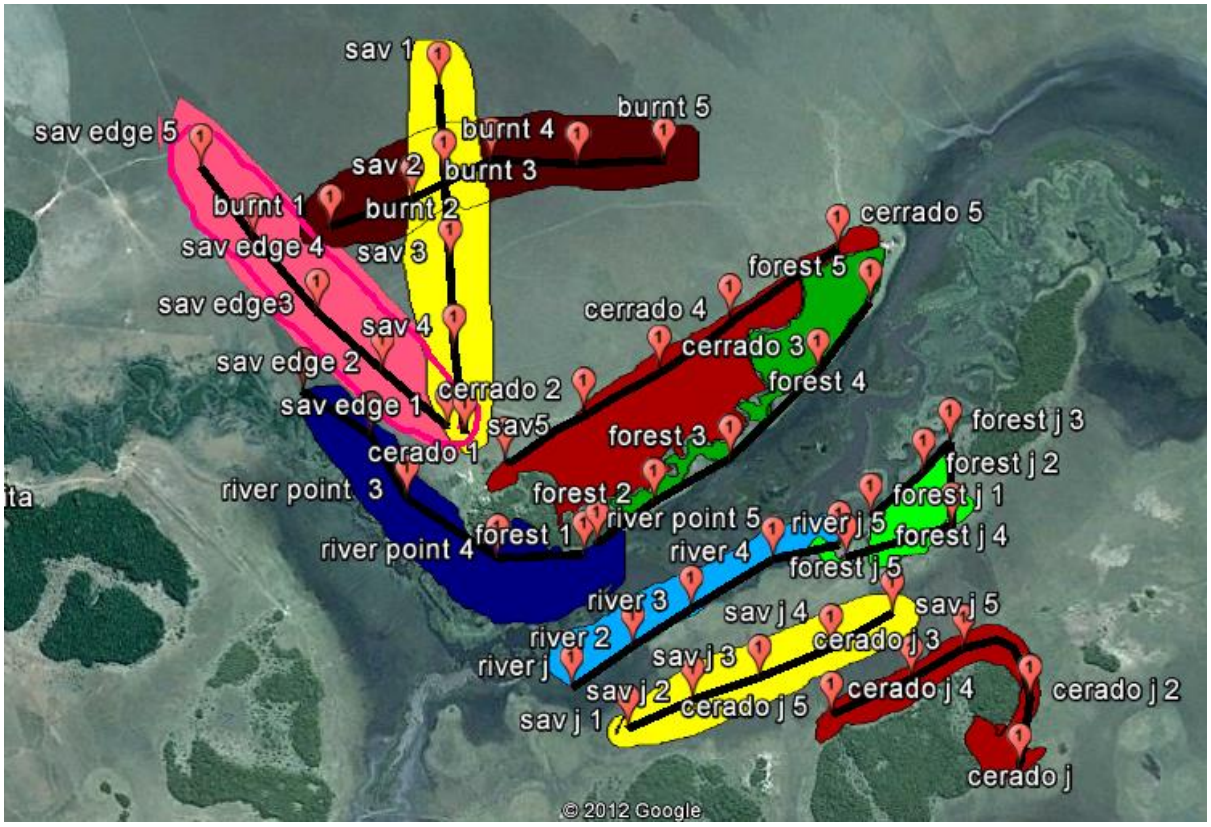

Figure 8.2: *Map of the point transects which were carried out across the reserves habitats. Transects north of the river represent those located in the protected, un-ranched land of the Reserva Barba Azul North (RBAN). Those south of the river represent those located in the un-protected, ranched land of the Reserva Barba Azul South (RBAS). The two new, post-fire transects are also indicated.*

Results & Discussion:

The numbers of individual observations for each species have been compiled (see figure 8.3). Vultures were the most frequently observed group. Caracaras were also abundant. Long winged harriers, great black hawk and savannah hawk were the most common otherwise.

Species	River	Savannah	Cerrado	Forest	Sav edge	Burnt	Total Observations
black Vulture	86	26	52	115	39	31	349
turkey Vulture	82	25	64	102	20	10	303
southern Caracara	32	15	16	40	14	13	130
yellow Head Caracara	4	0	6	5	5	4	24
long winged Harrier	12	0	0	3	3	0	18
Snail Kite	5	0	0	1	0	0	6
great black Hawk	3	0	0	0	0	3	6
Savannah Hawk	1	2	0	0	2	1	6
White Tailed Hawk	0	1	0	0	0	0	1
aplomado falcon	2	0	0	0	1	0	3
black collared hawk	3	0	0	1	0	0	4
black faced hawk	1	0	0	0	0	0	1
crane hawk	0	1	0	0	0	0	1
grey headed hawk	1	0	0	0	0	0	1
hook billed kite	0	0	1	0	0	0	1
lesser yellow headed vulture	3	0	4	2	4	4	17
roadside hawk	1	0	1	0	0	0	2
short tailed hawk	1	0	0	0	0	0	1
white hawk	3	0	0	1	0	0	4
zone tailed hawk	1	0	0	1	0	0	2

Figure 8.3: *Table showing the species observed throughout the survey for the Reserva Barba Azul North (RBAN) stratified by the habitat in which they were observed.*

Several nest sites were also identified throughout the study (see figure 8.4). We also captured numerous pictures of different species (see figure 8.1 and 8.5 to 8.9).

Figure 8.4: *Nest locations of raptors recorded throughout our time in the field using a hand-held GPS receiver.*

Figure 8.5: *Black vultures feeding on a capybara carcass. (photo by Jo Kingsbury)*

Figure 8.6: *Lesser yellow headed vulture soaring on thermals. (photo by Jo Kingsbury)*

Figure 8.7: *Juvenile yellow headed caracara (Milvago chimachime). (photo by Jo Kingsbury)*

Figure 8.8: *Southern caracara (Caracara plancus) feeding a snake to its chick (photo by Jo Kingsbury)*

Figure 8.9: *Black collared hawk (Busarellus nigricollis) perched on a fence post (photo by Jo Kingsbury)*