A Comparison of Abundance, Distribution and Behaviour at Pre-Roosting Time of the Critically Endangered Blue-Throated Macaw, *Ara glaucogularis*, and the Sympatric Blue and Yellow Macaw, *Ara ararauna.*

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Abstract

Determining the current population distribution and abundance of the Critically Endangered Blue-Throated Macaw, *Ara glaucogularis* is one of the primary aims for the BirdLife International Bolivian Partner, Asociación Armonía. Estimating the abundance and distribution of this species has proven to be difficult due to the heavily fragmented populations and the remote locations where the species is found. The Blue-Throated Macaw is endemic to Bolivia and has had little research conducted on its population, distribution and behaviour in the last 30 years since its rediscovery in 1982. This project collected information on the distribution, abundance and behaviour of *A. glaucogularis* and compared it to the sympiatric species *Ara ararauna* in the privately owned Paraba Barba Azul Nature Reserve in Bolivia.. The study used multiple evening point survey counts and individual forest island roost surveyes to estimate abundances and study pre-roosting behaviours of the two species. Analysis of the point count survey data showed that a minimum of 103 *A. glaucogularis* and 284 *Ara ararauna* were using the reserve prior to roosting. For *A. glaucogularis* this represents perhaps a third of the current global population of this critically endangered species meaning the reserve is probably the most important site in the world for its conservation. Comparing the data recorded in this project with a similar project carried out in 2009, the overall abundance of *A. glaucogularis* has increased. The data collected during the forest island surveys showed that although there were large evening congregations of both species they flew further afield and probably out with the reserve to roost. Despite the islands not being utilised for roosting the islands appeared to be used as important congregation points or 'stop-off' stations before flying away and precise details of the directional movements should allow future research to track down overnight roost sites.

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1. Introduction

1.1 General Introduction

The focal species of this study, the Blue-Throated Macaw, *Ara glaucogularis* (Dabbene, 1921), is a critically endangered endemic species to Bolivia found on Appendix I and II of CITES. This threatened species has suffered a large decline in its numbers over the last 30 year, primarily during the 1980's (BirdLife International, 2010). The species has a restricted habitat confined to Llanos de Moxos of the Beni Department in Northern Bolivia where in the wild it is found in savannah areas, gallery forest and forest islands (Yamashita, *et al*., 1997). As the population of species is heavily fragmented, it is subject to on-going conservation efforts by Asociación Armonía/Loro Parque Fundación, the Bolivian partner of BirdLife International. Asociación Armonía is a non-governmental organisation (NGO) who have an ongoing conservation programme that has involved intensive population and distribution surveys, searches for further populations as well as out reaching to the local communities via educational promotion (Hesse, *et al*., 2000) The known area occupied by *A. glaucogularis* is estimated to be of 8600km^2 which is largely fragmented with low numbers found in different parts of this area (Hesse, *et al*., 2000). Current population estimates vary, with BirdLife International (2010) estimating between 50 and 249 mature individuals with an estimated range of 12,900km^2 . However, Herrera and Hennessey (in press) predict the total population to be ranging between 250 and 300 individuals. The largest single count of this flocking species was 70 individuals at a seasonally dry roosting site observed in 2007 (IUCN, 2010).

After laws had been passed in 1983 against the trapping of *A. glaucogularis* and the subsequent law ceasing the live exportation of animals in 1984 (Hesse, *et al*. 2000), the IUCN classified the Blue-Throated Macaw as Threatened in 1988 (BirdLife International, 2010). The discovery of only a small population in surveys in 1993 (Jordan, *et al.* 1993) led to a reassessment of *A. glaucogularis* in 1993

resulting in it being reclassified as Endangered (BirdLife International, 2010); however the continual sharp decline in numbers observed over the last 30 years lead to the IUCN listing it as Critically Endangered in 2000 (BirdLife International, 2010).

1.2 Bolivia

Bolivia is a landlocked country within South America. It has an area of approximately 1,098,581km^2 (424,160mi^2) making it the 28th largest country in the world (The World Factbook, 2009). Bolivia is divided up into 9 departments where each department is divided further to give 100 provinces and then into individual municipalities and cantons (The World Factbook, 2009). To the west lie the Andes where the Bolivian Altiplano is found and to the North and East is the lowland Amazon landscape. To the South of the country lies the worlds largest salt flats, the Salar de Uyuni. Each region of Bolivia is distinct in its climate and geography. The Beni Department is found in the lowlands in the north of Bolivia and has a population of 420,000 (2006 census). Its capital is the city of Trinidad where the weather is continually warm/hot and humid with annual rainfall between 1000mm and 4000mm.

1.3 Birds and their Conservation in Bolivia

Due to Bolivia's lavish and prolific ecology, it is home to a vast array of species of birds. Hennessey et al. (2003) record 1398 species of bird in Bolivia which is approximately 45% of South American species (Ibisch 2005), including 50 species of psittacidae. This makes Bolivia the fifth richest in avifauna in the world. However, 65 of these species of bird are in some degree threatened with extinction.

The term endemism was re-defined by Stattersfield *et al*. in 1998 and used in the context of a bird species who has a restricted range of less than 50,000km^2 (Hennessey *et al*. 2003). If a defined area contained large number of such restricted range or endemic species then that area is deemed an Endemic Bird Area (EBA). The EBAs are designated areas by BirdLife International which are of the highest concern for habitat-based conservation for birds (BirdLife International, 2010) however these areas only account for 4.5% of the earth's terrestrial land. EBAs are found on every continent of the world usually containing between 2 and 80 restricted-range species. 70% of the earth's EBAs are found within the tropics or sub-tropical regions (BirdLife International, 2010). Bolivia contains 5 sites classified as Endemic Bird Areas and 4 Secondary Areas one of them being the Beni Lowlands (s027) (Hennessey, *et al*., 2003) to which the Blue-Throated Macaw, *A. glaucogularis*, is endemic (BirdLife International, 2010). The Beni Lowlands Secondary Area contains 4 'Important Bird Areas' (IBAs) which are sites that are most critical for conservation of threatened birds such as *A. glaucogularis* (BirdLife International, 2010)..

The Beni Department provides a valuable ecosystem as is able to support a significant number of Bolivia's bird species with 509 species been recorded (Beck, *et al.,* 1997). Much of Bolivia still has limited road access but as technological and industrial powers increase, these areas will be subjected to negative pressures resulting in the requirement of expansive active conservation efforts. The combination of rural poverty and disordered development has led to the damage and loss of biodiversity and valuable ecosystems which potentially could be lost completely if adequate conservation measures are not sought further. However, 19.4% of Bolivia's landmass is already under some form of conservation protection (EarthTrends, 2003).

1.4 Macaws in Bolivia

A. glaucogularis and *A. ararauna* are not the only macaws found within Bolivia. Bolivia is home to many other species of macaw, some of which are also under extreme threat. Within the psittacidae or parrot family there are 12 species of macaw that are found in Bolivia (Hennessey *et al.,* 2003). In addition to *A. glaucogularis*, the Red-Fronted Macaw, *Ara rubrogenys*, is also an Endangered species endemic to Bolivia. However, *A. rubrogenys* is found in the departments of Cochabamba, Santa Cruz, Chuquisaca and Potosí and not the Beni Department where *A. glaucogularis* is found (Hennessey *et al,* 2003). *A. rubrogenys* is also subjected to vigorous conservations efforts by Asociación Armonía.

1.5 Asociación Armonía and their involvement in Blue-throated Macaw Conservation

Asociación Armonía is the primary bird conservation organisation in Bolivia. It is a Non-Governmental Organisation and the Bolivian Partner of BirdLife International focused on conserving the threatened bird species of Bolivia. Asociación Armonía aim to locate areas known to inhabit *A. glaucogularis* and actively conserved them and have done since the project first started in 1993 after a small group of Blue-Throated Macaws were discovered in 1992 (Jordan and Munn, 1993). Since 1993, Asociación Armonía has focused on developing a comprehensive conservation programme centring around population and distributional surveys of *A. glaucogularis.* In 2006*,* Asociación Armonía began one of their most intensive programmes erecting nest boxes at sites known to be inhabited by *A. glaucogularis*. This programme unveiled the high demand for the nest boxes imposed by the Blue-Throated Macaws as it provided a suitable alternative to the nesting cavities in trees (BirdLife International, 2010).

1.6 Blue-Throated Macaw and Blue-and-Yellow Macaw Status and Ecology

Prior to the discovery of the small population in 1992 the localities of wild populations were largely unknown leading to the extensive search of further populations in 1993. Early records of *A. glaucogularis* suggest that this species was once found further south in Bolivia and also in Paraguay and Argentina. However, confusion may have occurred because the name *Ara caninde* (Caninde Macaw or Wagler's Macaw) (Ingles *et al*, 1981) was commonly used to identify and refer to both *A. glaucogularis* and *A. ararauna.*

The palm groves in the gallery forests are expected to be over 500 years old which means these forests were is existence before the Europeans colonised South America. It is recognised that the legal and illegal parrot captures that occurred during the 1980's was the main factor in the decline of this species and leading to its classification of critical endangered (Yamashita *et al.,* 1997). It is thought that during this time approximately 1,200 wild individuals were caught and exported out of Bolivia. A law was passed in 1984 to ban the live exportation of *A. glaucogularis*, but still to this day it is thought that illegal exporting still continues (Herrera & Hennessey, 2007). Asociación Armonía/Loro Parque Fundación conducts a parrot trade monitoring scheme which has not detected that presence of any Blue-Throated Macaws being illegally exported in the past two years (IUCN, 2010).

The Blue-Throated Macaw habitat is composed of forest fragments which are surrounded by seasonally flooded savannah and gallery forest stretching along water courses on land elevated between 130m and 235m (World Wild Life Fund, 2008). These forest fragments are occupied mainly by palm groves of the Motacú palm (*Attalea phalerata*). *A. glaucogularis* is a palm fruit specialist as it feeds on the mesocarp layer of the fruit and doesn't eat the nut itself (Hesse *et al,* 2000). Jordan *et al.* (1993) reported *A. glaucogularis* also opens the nuts to drink the liquid from the immature or

unripe motacú palm nuts and states that it also feeds on the nuts of the palm species *Acromia aculeata*.

The Blue and Yellow Macaw, *Ara ararauna* (Linnaenus, 1758), has a close morphological resemblance to *A. glaucogularis* and live sympatrically in the same environment. Unlike *A. glaucogularis t*his species has a large geographical habitat range covering several countries in South America with an estimated area of 7,730,000km^2 (BirdLife International, 2010) and is listed under CITES Appendix II and is classified by the IUCN (2010) as of Least Concern. Even though *A. ararauna* encounters the same threats as *A. glaucogularis* including, trading, deforestation and habitat destruction, the populations have not declined to the same extent.

The social aspects of *A. glaucogularis* remains largely unknown. They are more frequently found together in pairs however have been noted to socialise in small groups of 7 to 9 (IUCN, 2010). It has been noted that there is a possibility that *A. glaucogularis* is a more sociable species given that their flock sizes are thought to be larger (IUCN, 2010).

1.7 Barba Azul Nature Reserve

In July 2008, Asociación Armonía/ Loro Parque Fundación purchased the San Lorenzo ranch with the support of the American Bird Conservancy and the World Land Trust, US. This area of land was previously a privately owned cattle ranch and after purchase was renamed the Barba Azul Nature Reserve whose most important aim was to help conserve the Blue-Throated Macaw. The reserve is located in the Beni Department of Bolivia (figure 1). It measures approximately 4kmx7km and has an area of 8,778 acres. This area was purchased in order to study, protect and conserve a population of *A. glaucogularis* found to be residing on a large forest island within the reserve. As of April 2010,

using the data collected from the University of Glasgow 2009 Expedition to the Barba Azul Nature Reserve and further information from Mauricio Herrera and Bennett Hennessey, 240 species of bird were known to inhabit the Barba Azul Nature Reserve, several of them being of special conservation concern as well as numerous species of mammals (Hennessey, 2010).

The Barba Azul Nature Reserve consists of a variety of ecosystems. The majority of the reserve is composed of savannah grassland. Located to the south of the reserve is a large gallery forest island with the River Omi situated along the southern perimeter of the reserve (figure 2). Cerrado habitats can be found along the northern edge of the main forest island acting as a transition zone between the gallery forest and the savannah grasslands. Scattered around the reserve in the savannah grasslands are smaller forest islands that have formed on slightly higher areas.

Figure 1. Location of the Barba Azul Nature Reserve.

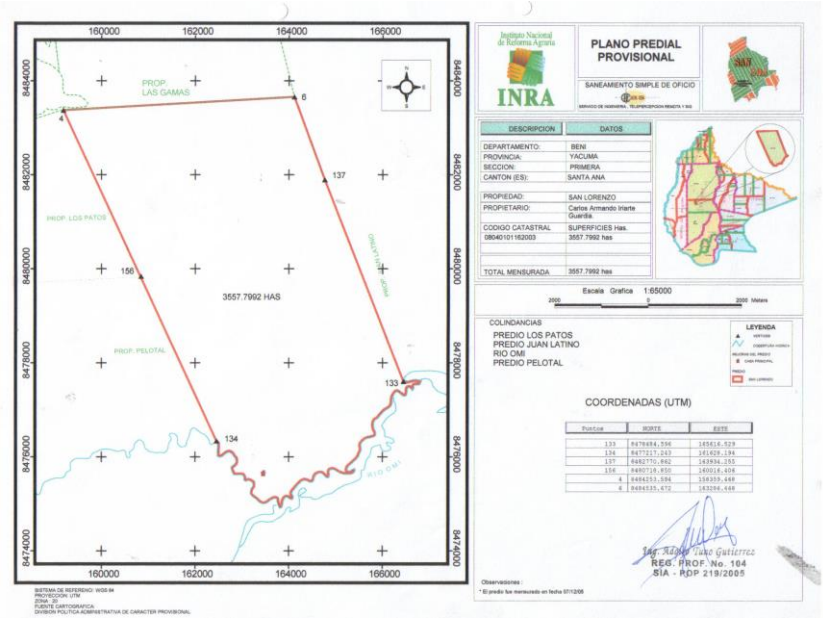

Figure 2. GPS location of the Barba Azul Nature Reserve

On the 1st of September 2010, with the help of three partner organisations: American Bird Conservancy, Asociación Armonía Bolivia and World Land Trust US, a further 2,867 acres of land was purchased extending the Barba Azul Nature Reserve to 11,555 acres (figure 3). The extension of the Barba Azul Nature Reserve not only protects this fragile ecosystem from the destructive burning of grassland and deforestation but also allows for the protection of other vulnerable and near-threatened species such as the Jaguar (*Panthera onca*), Giant Anteater (*Myrmecophaga tridactyla*) and Pampas Deer (*Ozotoceros bezoarticus*) as well as many bird species of conservation concern (table 1). The reserve is currently not open for tourism however construction is under way to open the reserve for tourism by 2011.

Figure 3. Locations of the Barba Azul Nature Reserve, Juvena and neighbouring ranches.

Species Name	Common Name	IUCN Status
Ara glaucogularis	Blue-Throated Macaw	Critically Endangered
Harpyhaliaetus coronatus	Crowned Eagle	Endangered
Elethreptus candicans	White-Winged Nightjar	Endangered
Alectrurus tricolor	Cock-Tailed Tyrant	Vulnerable
Alectrurus risora	Strange-Tailed Tyrant	Vulnerable
Coryphaspiza melanotis	Black-Masked Finch	Vulnerable
Rhea americana	Greater Rhea	Near Threatened
Neochen jubata	Orinoco Goose	Near Threatened

Table 1. List of some of the threatened birds found within the Barba Azul Nature Reserve.

Threatened status according to IUCN (IUCN, 2010).

1.8 Current Threats

All the current sites which contain sub-populations are found within privately owned cattle ranches. A common threat to these environments is the periodic burning and clearing of land to provide pasture for cattle (Hesse, *et al.* 2000). The felling of trees, in particular *A. phalattera,* is also a considerable problem as this tree is not only utilised for feeding by *A. glaucogularis* but it is also a valuable breeding and nesting area where they construct their nests are within the hollows in the trunks of the palm. Inter-specific competition from other species such as toucans, woodpeckers and other macaws may add to the reduced chances of *A. glaucogularis* finding suitable nesting sites as these species compete for the same nesting environment.

Despite these declines over the past 30 years, there are signs that the population is slowly increasing due to conservation efforts imposed by Asociación Armonía and the abolishment of trade (BirdLife International, 2010). However, due to the severe fragmentation of the populations, concerns are raised regarding the genetic fitness of the remaining populations.

1.9 Previous Studies & Aim of this Study

Due to the the fragmented distribution, low populations and its endemism there has been little published work and information regarding the natural history, behaviour and distribution of *A. glaucogularis.*

In August 2009, a baseline study was conducted within the Barba Azul Nature Reserve by a group of students from the University of Glasgow and Bolivian scientists. This study collected provisional abundance data for *A. glaucogularis* among other species and provided a baseline for this more detailed current study to be compared to. From work previously carried out in 2009 within the Barba

Azul Nature Reserve, it has been estimated that the areas held approximately 70 individuals in the dry season and 20 individuals in the rainy season. Combining this data with the ranches in the same general area of the Beni it is hoped that the area might hold an estimated 40% of the worlds wild population of Blue-Throated Macaws.

This study aimed to quantify the abundance, distribution and aspects of behaviour of the endemic Blue- Throated Macaw, *Ara glaucogularis*, in comparison to the more prevalent Blue and Yellow Macaw, *Ara ararauna.* To do this work focused on the pre-roosting hours when parrots were easier to observe and count as they gathered into flocks prior to roosting. In particular the aims of this study are to:

1. Carry out regular counts of the Blue-Throated Macaw, *A. glaucogularis* and establish birds pre-roost movement patterns within the Barba Azul Nature Reserve in comparison to the Blue and Yellow Macaw, *A. ararauna.*
2. Assess whether there are inter-specific behavioural difference in pre-roosting behaviour between *A. glaucogularis* and *A. ararauna.*
3. Estimate the total population size of *A. glaucogularis* using the Barba Azul Nature Reserve.

2. Materials and Methods

Data for this project was collected in a variety of ways consisting of 2 main collection methods as well as general habitat surveys.

The team of data collectors comprised of 5 under-graduate students (3 Zoology students, 1 Marine and Freshwater Biology student and 1 Geography student) and 2 Zoology graduate students from the University of Glasgow and 1 Bolivian student from Universidad Autonoma Gabriel Rene Moreno. The majority of students had previous experience of collecting ornithological data. Prior to the commencing of the project, members of the team were given a week to gain experience in recognising the morphological and audible differences between *A. glaucogularis* and *A. ararauna.*

2.1 Island Surveys

The distribution and population data for *A. glaucogularis* and *A. ararauna* were conducted over a period of 5 weeks from the 2nd of August 2010 until the 4th of September 2010. Prior to the commencing of the forest island survey, forests islands that could be used in the study were located in the initial week. In total 6 forest islands (Table 2) within the surrounding savannah were found , prior to the survey it wasn't known which islands the macaws were using regularily. On the northern perimeter 4 forest islands were found in a line. When faced north, the second and fourth island in the row, from left to right, was chosen to be represented in the surveys as islands 5 and 6 respectively. A preliminary visit to each of the islands was done in the week prior to the start of the systematic survey in order to familiarise with the terrain and the travelling distance. The terrain was explored on foot or by horseback if the island being surveyed was at a considerable distance. Islands which *A. glaucogularis* were thought to use at least occasionally were located via information from

locals from neighbouring ranches and from associates of Asociación Armonía who had visited the Barba Azul Nature Reserve before. Islands were included in the survey even if it was unknown if *A. glaucogularis* utilised them. Each forest island was then visited systematically over the 5 week period and in total 30 days of research was conducted.

Information collected at each site included data for both *A. glaucogularis* and *A. ararauna*. The data gathered was as follows: date, site and G.P.S location of observation point, the weather conditions, number of flocks observed, numbers of individuals within each flock, direction of macaw travel, the time of arrival and departure, the distribution of the macaws in the tree structure, ratio of adults to juveniles (if detectable) and notes on behaviour exhibited were also recorded. Pre-roosting time was determined to be one and a half hours prior to sun down based on the sightings of departure from the main island of both species of macaws in the initial week. It was therefore ideal to be at the forest islands at 17:00 local time and observe them until 18:30 local time. Visual observations were conducted using either 8x40 or 10x40 magnification 'Bushnell' binoculars. Location data was recorded with hand held Garmin Etrex Global Positioning System (G.P.S) devices.

Island	G.P.S Location	Distance to Main Forest Island (m)
1	S13°45.844' W066°07.026'	178
2	S13°43.817' W066°06.540'	2189
3	S13°44.525' W066°05.538'	810
4	S13°44.583' W066°05.775'	413
5	S13°41.586' W066°08.138'	7223
6	S13°41.427' W066°07.839'	7185

Table 2. Locations of all the islands visited in the island surveys and their approximate distance from the main forest island.

2.2 Point Count Surveys

A pre-roost population count was also conducted for both *A. glaucogularis* and *A. ararauna*. Three stations were chosen at widely sepearte points around the main forest island where a maximum viewing distance was possible from the observation points. The first station was located at the most easterly point at the end of the main forest island with GPS location S13°45.491', W066°07.186'. The second station was located on the south side of the main forest island along the River Omi with GPS location S13°45.870', W066°06.990'. The third station was initially located approximately on the northside of the island 200m from the main camp at G.P.S location: S13°45.491', W066°07.186'. After 3 days of observation it was found that visibility of macaws leaving the forest was somewhat obstructed so this point was then moved to a location with a better all round view, 800m east along the man-made track running along northern side the main forest island at the G.P.S point:

S13°45.297', W066°06.800'. One or two people were allocated to a station on each visited and each station was visited simultaneously twice a week starting at 5 o'clock and ending at half past 6 in the evening. Each observation of either *A. glaucogularis* or *A. ararauna* was noted along with the time, numbers of individuals at that time, the direction they were flying in and any other observations that were noteworthy.

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

Table 3. G.P.S locations of the stations in the point count surveys. * indicates the G.P.S point for this station utilised in the first 3 days of data collection.

In selecting the most suitable monitoring method for measuring abundance the use of other methods of population sampling such as capture-mark-recapture were considerd, but were not used due to such small numbers within the population and the high disturbance this method would have involved. It was decided that to reduce any physical impact on the natural behaviour of *A. glaucogularis* and *A. ararauna* the studies should be conducted by counting the individuals as precisely as possible from a reasonable distance where behaviour was still able to be recorded. In order to reduce the chances of interfering with their natural behaviour, a man-made hide was erected in order to conceal the observers if the viewing point was extremely exposed. Each observation was conducted predominantly by 2 or more observers but on occasions only one observer was conducting the research, given the open view across the savannah and the visibility of

flying birds the number of observers appeared to have little impact on how many birds were detected. Considerable care was taken in identifying each individual in order to achieve accurate results.

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

2.3 Habitat and Ecological Surveys

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

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

2.4 Data Analysis

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

3. Results

Figure 1 and 2 show the location of the Barba Azul Nature Reserve where the research was conducted for the project. A total of 30 islands surveys and 36 point survey counts were used in the analysis.

3.1 Island Surveys

The overall result from the island surveys showed that the tendency for *A. glaucogularis* to perch within the islands was rare. Accumulating the results from all the islands there was a total of The was no evidence observed of *A. glaucogularis* feeding within the forests due to no fruits being present upon the Motacú palm trees. Island 4 proved to be the island which saw the largest accumulation of *A. glaucogularis* at one time on many occasions however, this island was not utilized as a roosting site over night by either of the species.

Conducting a Spearman Rank Correlation Coefficient and creating the corresponding scatter plot, figure 4, a relationship between the area of each island used in the island surveys and the distance of the islands from the main forest island was analysed. The scatter plot (Figure. 4) showed no direct relationship and the Pearson product moment correlation coefficient confirmed this with r = -0.371.

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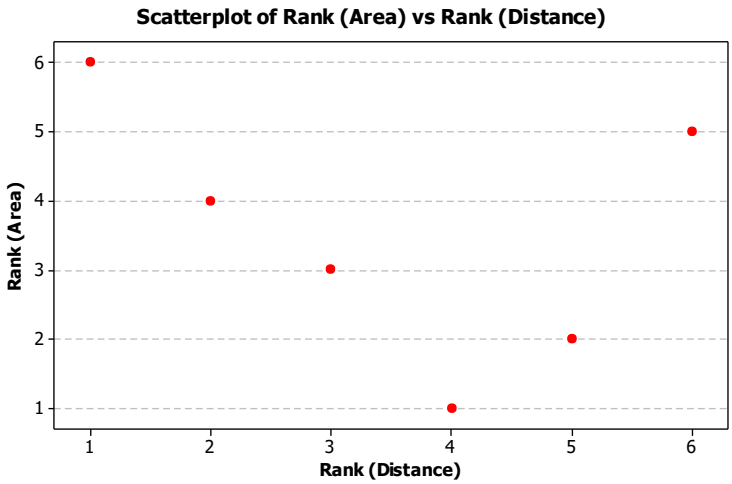

Figure 4. Scatter Plot illustrating the inverse relationship between the ranked data of each islands area and the distance of each island from the main island.

The Spearman Rank Correlation Coefficient, r_s, were calculated to see if there were any relationships between, the numbers of *A. glaucogularis* in each island, the distance of the forest island from the main island and the area of the island.

r_s(*number of individuals*$_{A.\ glaucogularis}$, *distance)*= -0.058

r_s(*number of individuals*$_{A.\ glaucogularis}$, *area)*= -0.580

r_s(*number of individuals*$_{A.\ ararauna}$, *distance)*= 0.268

r_s(*number of individuals*$_{A.\ ararauna}$, *area)*= -0.638

The level of significance for N = 6 in a two-tailed test in relation to the critical values of of Spearman's rank correlation coefficient for P = 0.05 equals to 0.886. This value shows that there is no relationship between these factors.

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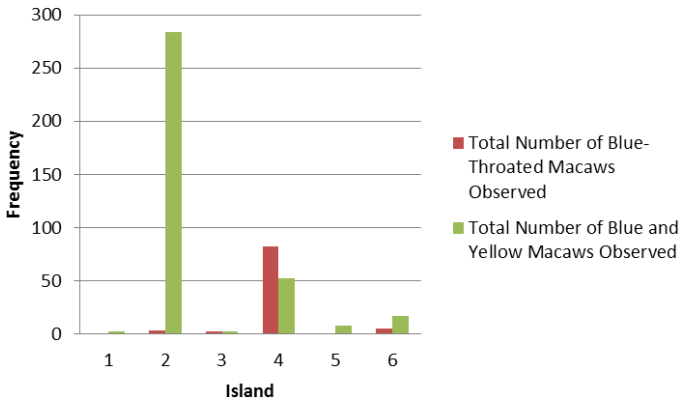

Figure 5. Frequency of individuals observed utilising the island.

The numbers of individuals who were observed utilising the island and remained in the island up to the end of the observational period is illustrated in figure 5. Low numbers of both species were recorded in islands 1, 3, 5, and 6. Island 2 had a exceptionally high number of Blue and Yellow Macaws in the island in comparison to the other islands however, there was only 2 Blue-Throated Macaws observed on island 2. Island 4 had a considerably larger number of individuals utilising the island than the other islands and, on the island, a greater number of Blue-Throated Macaws (N = 82) was observed than Blue and Yellow Macaws (N = 52).

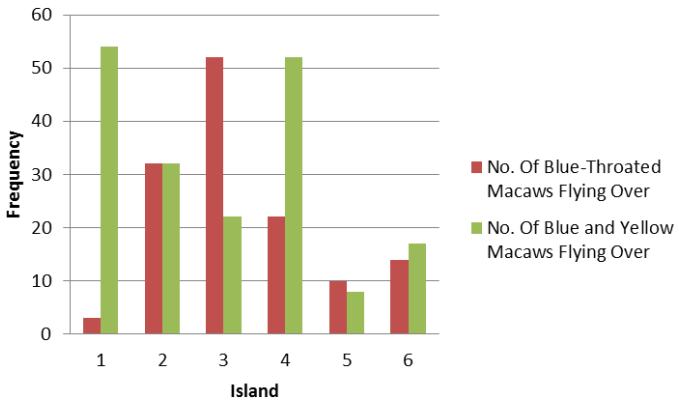

Figure 6. Frequency of individuals observed flying over the islands without utilising the islands.

The total number of individuals observed flying overhead were recorded in addition to the numbers utilising the islands. Figure 6 shows that there was a large variance in the numbers of individuals recorded depending on the location of the observation. The observations showed that there was a large number of Blue and Yellow Macaws observed flying over station 1 located yet there was few records of Blue-Throated Macaws in the vicinity. Equal numbers of each species was observed at station 2 however there were large numbers of both species flying overhead at islands 3 and 4 which are located close to the main forest island. Islands 5 and 6 located in the north of the reserve saw similar numbers of Blue-Throated Macaws ($N_{Island\ 5}$ = 10, $N_{Island\ 6}$ = 14) and Blue and Yellow Macaws ($N_{Island\ 5}$ = 8, $N_{Island\ 6}$ = 17).

3.2 Point Count Survey

The frequency of *A. glaucogularis* (N = 109) observed was considerably lower than *A. ararauna* (N = 354). The majority of *A. glaucogularis* sightings were in pairs (N = 41) or of small groups of between

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3 and 6 (N = 41). Sightings of flocks of over 6 individuals were also recorded on a daily basis (N = 13). The largest flock recorded departing from the main island was of 58 *A. glaucogularis* and the largest number of separate individuals recorded leaving the island on one day was 103 on 04/09/2010. No individuals were recorded flying into the island at this time of the day so these figures represent the minimum number of individuals using the reserve.

Commented [RCM5]: It would be good to have a figure or table showing the total numbers of individuals and flocks seen leaving the main island during each survey day

	Station 1	**Station 2**	**Station 3**
Mean	4.82	2.57	7.45
Median	3	2	2.5
Variance	41.10	1.56	177.16

Table 4. Descriptive statistics for the numbers of *A. glaucogularis* observed in the point counts.

	Station 1	**Station 2**	**Station 3**
Mean	4.81	4.22	5.33
Median	3	3	3
Variance	25.05	9.97	39.45

Table 5. Descriptive statistics for the numbers of *A. ararauna* observed in the point counts.

Initial visual observations of the raw data for the point count surveys showing the directional movements of both the Blue-Throated Macaws, *A. glaucogularis* and Blue and Yellow Macaws, *A. ararauna* show that the vast majority of individuals are flying in a northerly direction away from the

forest island at pre-roosting time as seen in figures 7 and 8 . Northerly directions included ranges between north-west and north-east and southerly directions included south-east and south-west.

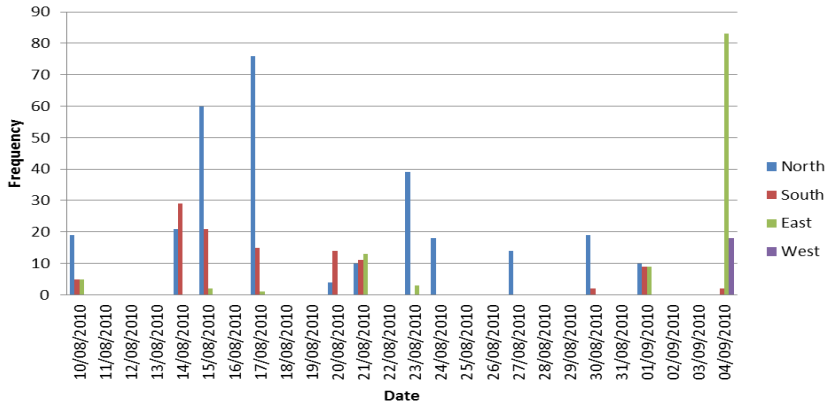

Figure 7. Daily directional movement of *A. glaucogularis* from the main island during during the point counts.

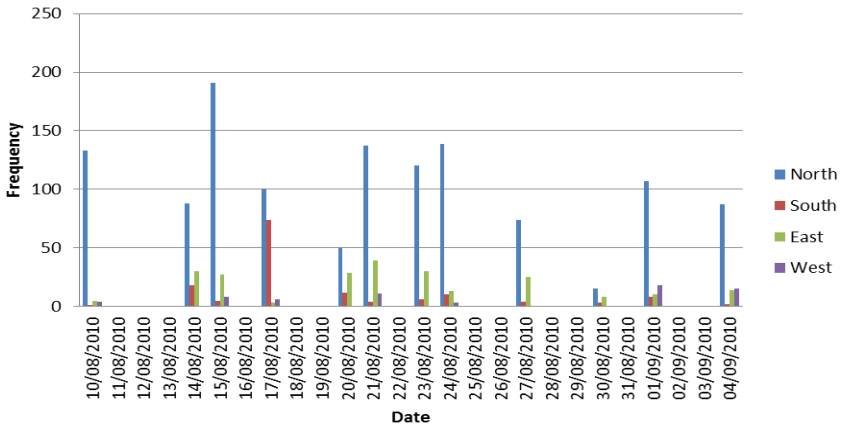

Figure 8. Daily directional movement of *A. ararauna* from the main island during the point counts.

Initial interpretations during the study recognised that there was a trend demonstrated, especially at station 1, for *A. glaucogularis* to depart from the main island prior to the peak time of the Blue and Yellow Macaws (Figure 9). It was recognised from the observations that *A. glaucogularis* departed approximately 1 hour prior to *A. ararauna* whilst *A. ararauna* continued to depart from the main forest island up to approximately 2 hours of observation. The sum of all *A. glaucogularis* observations (N = 532) over the period was used in this analysis. This is not a representation of the population but a representation of the significance of departure time in relation to the abundance. Each interval used in the analysis was of 20 minutes in length and the most observations were recorded between 00:00 minutes and 00:20 minutes of observation (N.B. 00:01 minutes being the point of the first observation of either *A. glaucogularis* or *A. ararauna*.) The number of observations within each time period decreases as the length of time increase in accordance with the observed hypothesis.

Commented [RCM6]: Refer to figures and do you have a statistical test for this

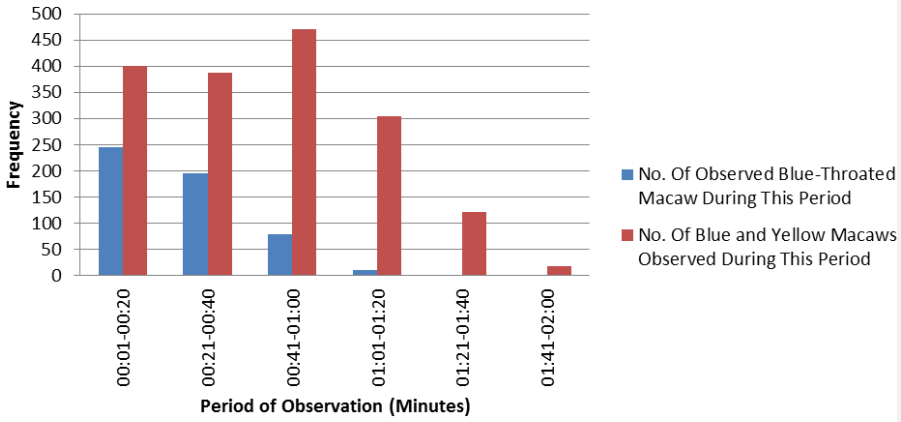

Figure 9. Number of individuals recorded during in intervals of 19 minutes.

Using the original data,the Mann-Whitney U-test for unmatched data was conducted using the ranked data from the total observations of each stations point count on each day. This non-parametric test used the medians of each *A. glaucogularis* (N = 25) and *A. ararauna* (N = 34) populations. The output value of W = 637.0 gives a p value of 0.0844. This value shows that there is 95.1% Confidence Interval at (-10.001,1.000). The outcome of this test shows that there is statistical evidence that the numbers of individuals in the two populations differ as the test is significant at 0.843.

Commented [RCM7]: What is being tested here?

The One-Way ANOVA application was used to analyse the variance in the data of the numbers of *A. glaucogularis* observed. In order for the models to calculate the answers the data had been logarithmically transformed by $\log_{10}(x+1)$ to provide a normal distribution in the data as seen in figure 10.

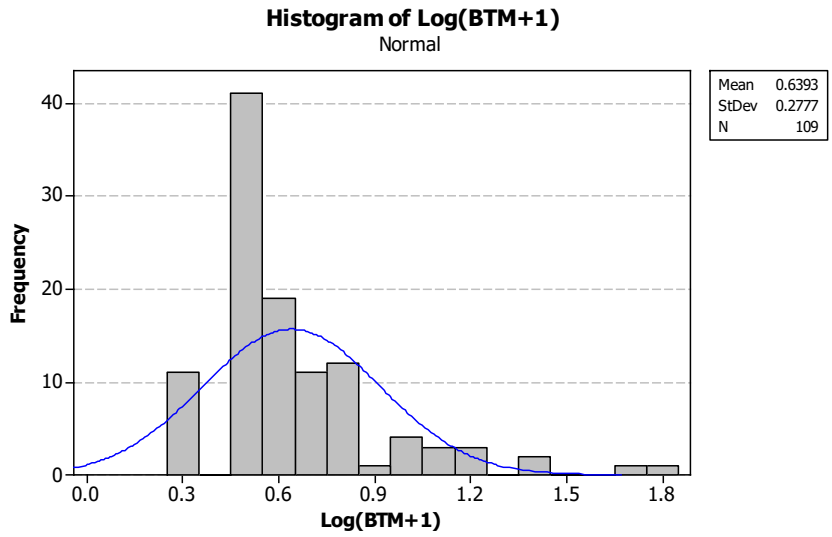

Figure 10. Logarithmically transformed instances of observed numbers of Blue-Throated Macaws.

The logarithmically transformed data in relation to the numbers of *A. glaucogularis* and the original data for *A. ararauna* recorded at each station on each day was analysed in the One-Way ANOVA tests. The One-Way ANOVA test showed that there was no significant relationship in log(BTM+1) and the station they were recorded at (P=0.068) however there was a significant relationship (P=0.007) for the untransformed numbers of observed *A. ararauna* and the station they were recorded at. Chi-Squared tests were manually calculated to assess if the distribution of frequencies between the stations is homogeneous. The results show that all values calculated from the point count surveys show that the observed frequencies recorded from the 3 stations are significant different in relation to the expected frequencies. This illustrates the proposition that there are more individuals seen at some stations than others over the study period. This is consolodated by figure 11 which displays the total frequencies of observed individuals at each station. This figure shows that station 1 recorded the most sightings of *A. glaucogularis* and *A. ararauna* then station 3 and the least at station 2.

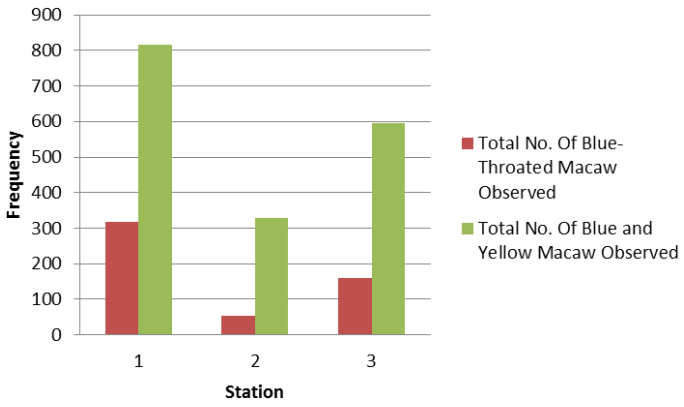

Figure 11. Total number of observed individuals recorded during the point counts.

The overall results show that there is a larger numberof *A. ararauna* observed within the Barba Azul Nature Reserve. Yet the numbers of each population fluctuates on a daily basis as seen in figure 12. This figure illustrates that the maximum number of *A. glaucogularis* is N =103 and the maximum number of *A. ararauna* is N =284. These numbers represent the minimum number of individuals in the population.

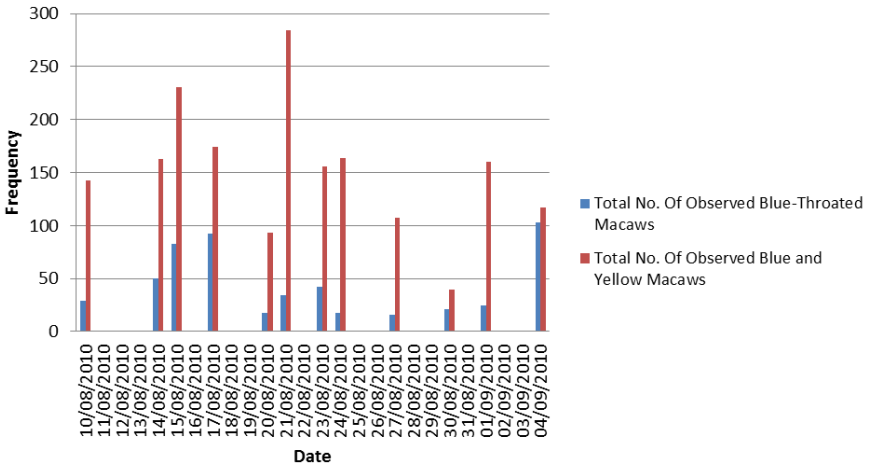

Figure 12. Total number of observed Blue-Throated Macaws and Blue and Yellow Macaws during the point count surveys.

A final notable observation was that as the weather change from the normal hot and dry conditions, the number of observations of both *A. glaucogularis* and *A. ararauna* notably decreased.

All the observations were taken from within the Barba Azul Nature Reserve as we did not have permission from the neighbouring ranch owners to have access to their land. It was however evident to the South on the other side of the river, the neighbouring ranch of 'Juvena' that there

were significant numbers of macaws in that vicinity. However, it was not possible to tell whether the macaws on the other side of the river were *A. glaucogularis* or *A. ararauna* due to the distance between the observer and the macaws.

3.3 Behavioural Observation

There were few instances where notable behaviour was observed, whether it was inter-specific or intra-specific. However, the situations where behaviour was exhibited by *A. glaucogularis* and *A. ararauna*, provided valuable information. There were a couple of instances observed where both the Blue-Throated Macaws and Blue and Yellow Macaws were interacting. The first was on the 10/08/2010 at 17:31 during a point count survey at station 3 and the far end of the main island. This sighting was solely of a mixed flock of 3 *A. glaucogularis* and 7 *A. ararauna* individuals. There was no inter-specific interaction occurring during this sighting but it was evident that these individuals were flying in the same direction away from the main forest island within the same flock.

At station 2 on 24/08/2010 there were numerous marked behavioural observations. Firstly, 10 Blue-Throated Macaws were observed at 17:21 continually taking off then landing again on the edges of the main forest island before their eventual departure to the north. During this period they flew to the river and were observed drinking beside a group of Blue and Yellow Macaws at which were circling around the river and also drinking from it. The two groups of macaws were observed mixing together however it was noted that the Blue-Throated Macaws were more discouraged to drink when members of the Blue and Yellow group were in immediate proximity to them.

A second pair of Blue-Throated Macaws were also observed this day at 17:51 however, this pair kept their distance from the group of Blue and Yellow Macaws who were drinking and then flew off to the

north. At the same time, another group of 3 Blue-Throated Macaws were they take off from the main island to the river to drink but then fly off to the south towards the 'Juvena' ranch. On this same day there were a large group of 11 individuals who transpired to be more vocal than other individuals previously seen. This large group of individuals were also observed circling overhead many times before flying off north.

3.4 Island Habitat and Ecology

Each island which was utilized in the pre-roosting island surveys was assessed for their botanical features and dimensions. Each island surveyed varied in size, with island 1 being the largest estimated at 21642m^2 and the smallest island being island 2 estimated at 1256m^2 as shown in table 6. The only island which was not of the same circular shape as the others was island 4 where it was of a triangular shape.

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

Table 6. Calculated area for each forest island studied in the island surveys and circumference.

Each of the islands visited were agreed upon by the botanist that they all share a similar flora composition. The islands were dominated by the Motacú palm species (*A. phalerata*). There was no presence of fruits upon any of the Motacú palm trees in any of the islands however there were old fallen nuts on the floor of the islands. These nuts had evidence of the mesocarp layer been eaten by both *A. glaucogularis* and *A. ararauna.* As described by Yamashita *et. al*. (1997), *A. glaucogularis* consumes the mesocarp layer of the Motacú palm nut by puncturing the apex of the nut and removed the outer layer of the nut before scraping and consuming the mesocarp layer latitudinally across the nut as seen in picture 1.

Commented [RCM8]: Better in methods?

Picture 1. Motacú palm (*A. phalerata*) nut. Left showing the mesocarp layer scraped latitudinally by *A. glaucogularis*. Right, a Motacú palm nut uneaten.

The ecology of island 4 proved to be different from the other 5 islands used in the island surveys. It was evident that on island 4 *A. phalerata* was not present. The trees within this island were sparsely distributed and upon identification by the botanist the tree, *Vochysia thyrsoidea*, dominated the

centre of the island. This tree emerged higher above the canopy than any other species of tree in this island and was estimated between 12m and 15m in height. There was no indication of any fruits upon this tree, nor on any of the other trees within this island. *V. thyrosidea* was the tree that the Blue-Throated Macaws were observed on many occasions congregating in during the point count surveys at station 3. A nest box put up previously by Asociación Armonía was present on this tree however, there was no evidence of it being utilised by the macaws as it had been infested with termites. Although the islands surveyed were situated in a range of land which is classified as seasonally flooded, there was no evidence of the flooding having recently affecting the land where the islands were situated.

Commented [RCM9]: Generally the results are a bit descriptive, more use of specific numbers would be good

4. Discussion

The first aim of this study was to estimate the abundance of *A. glaucogularis* within the Barba Azul Nature Reserve through point survey counts and island surveys and collect data on their directional movements from the main forest islands out to the smaller forest islands where they roost and compare this to the abundance and movements of the sympatric species *A. ararauna*. The second aim was to record the natural inter-specific behaviour between *A. glaucogularis* and *A. ararauna* during the island surveys and point count surveys. This discussion examines these aims through the analysis of both of the observational types thus providing and up to date record of the status of *A. glaucogularis* within the Barba Azul Nature Reserve.

The team of observers were given one week in order to allow themselves to recognise the differences between *A. glaucogularis* and *A. ararauna* during the studies so error in observer judgement was not a factor and all observations could be regarded as accurate.

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

4.1 Island Surveys

Exploration of the reserve in the first week on the reserve enabled the forest islands to be located where *A. glaucogularis* were believed to reside. Some islands were also chosen where it was unknown if they were utilised by *A. glaucogularis* to act as a control and to consider the possibility of discovering islands utilised. Observation time was constricted to the pre-roosting period in the interest of safety to allow for the observers to travel back to the camp site with maximum day light.

The Spearman's Rank Correlation Coefficient was used to analyse the relationship between the area of the islands and the distance of the islands from the main forest islands in relation to the numbers of *A. glaucogularis* and *A. ararauna* recorded utilising the islands potentially after night fall. The non-parametric Spearman's Rank Correlation Coefficient was used instead of the more accustomed Pearson's Product Moment Correlation Coefficient as the data used in the analysis was not normally distributed and the outliers would have distorted the results. The results from this analysis determine there is no relationship in the numbers observed with the dimensions of the islands. It was expected that the larger the forest islands the more individuals roosted in the islands and that there was a greater chance of more individuals roosting in the islands further away from the main island. From these observations it is safe to conclude that *A. glaucogularis* do not utilise the smaller forest islands within the Barba Azul Nature Reserve to the extent that was expected. The project established that there are a large number of *A. glaucogularis* and *A. ararauna* which do not reside in the smaller forest islands during the night. From the surveys that were conducted up at islands 5 and 6 on the northern perimeter of the reserve, flocks of *A. glaucogularis* and *A. ararauna* were observed flying further afield to the north into the 'Las Gamas' ranch and possibly further afield.

In surveying the habitat of the islands none of the Motacú palms showed any sign of fruiting proving that the macaws did not use these islands for feeding and confirmed that they exploit the main

forest island for feeding purposes. However, scattered across the floor of the islands were old nuts which had fallen from the trees indicating that they had already fruited earlier in the year in accordance with Barthlott *et al*. (1998) who states that the Motacú palm fruits earlier in the dry season and in the onset of the wet season. In relation to this fact it is not wise to rule out the possibility that these islands may be used for feeding at different times of the year from when the project was conducted.

Towards the end of the project work there were more instances of days where the weather was not the typical hot and dry as normally experienced. When abnormal weather such as high winds or dull atmosphere was experienced the numbers of individuals recorded decreased. It is postulated that *A. glaucogularis* and *A. ararauna* may reside within the main forest island overnight if weather conditions are poor to depart out to the smaller forest islands however there is no evidence either observed or recorded of this occurring.

It is possible that the results recorded in relation to the behaviour would have underwent inter-observer variation. Each observer interpreted the behaviour of the birds differently and some behaviours may have gone unnoticed due to this. Therefore, it was not possible to analyse the behaviour recorded in any more detail than what was stated.

In investigating and understanding the behaviour of *A. glaucogularis,* interest was pursued in looking into the social structure of the flocks. The island surveys showed that both *A. glaucogularis* and *A. ararauna* distribute themselves either clustered (N = 10) or randomly (N = 2) yet there is the possibility that observer differences may have altered the results. Observer differences may also be a factor in the classification of where the flocks are positioned in the trees. This was kept to a minimum by allocating at least two observers to partake in each island survey.

4.2 Point Count Surveys

The points where the observations were to take place were chosen with respect to the maximum viewing capacity and reducing the potential of overlapping the observation range from the other points. This allowed for all individuals recorded to be classified as separate individuals allowing for an accurate population count. The stations were all positioned at significant points at approximately equal distances from one another around the main forest island allowing for a large geographical range. The original point for station 2 was approximately 200m from the main camp however, this point was relocated after 3 days of observation to a point located a further 600m along due to the restricted view by an out crop of trees from the main forest island.

Firstly, visual analysis of the raw data on the directional movements from all three of the point count stations, the vast majority of *A. glaucogularis* fly from the main forest island out in a northerly direction. This can be confirmed by the histograms depicting the directional movements of *A. glaucogularis* and *A. ararauna* individuals observed on each day in figures 4 and 5. The most logical reason explaining this direction of travel was derived from the preliminary exploration of the reserve in the initial week. Located towards the north of the reserve there were an abundance of smaller forest islands around the perimeter and further afield out into the 'Las Gamas' ranch and other ranches out with the reserve.

It was clear from the first hand analysis of the raw data collected that station 1 located at the most easterly point of the main forest island exhibited significantly higher numbers of *A. glaucogularis* observed. However, when it came to analysing the data the use of the raw data had to be logarithmically transformed due to the large range of variation within the original data which resulted in the variance of the sample count data being considerably greater than the mean creating

a unnatural skew to the left in the distribution. By adding 1 to all the data it was possible to then conduct a logarithmic transformation with the equation $\log_{10}(\chi+1)$.

On the 14/08/2010 an observation of 27 individuals was recorded at station 3 however, this had to be omitted from the results as it was unclear to the observer the numbers of each species contained within the flock due to the far distance they were observed at.

The One-Way ANOVA test failed to provide any statistical conformation that there was any relationship between the numbers of *A. glaucogularis* observed depending on which station they were recorded at which was seemingly apparent from the visual observations of the raw data. In order to investigate further where there was indeed a relationship Chi-Squared Tests were conducted on the data.

As there were three stations chosen in the point count surveys there is the hypothesis that each station will observe equal numbers of individuals of each species. In order to analyse the homogeneity of this hypothesis a Chi-Squared Test was conducted. The Chi-Squared Test was rendered useful in that it proved that the distribution of the observations was not equal. From the Chi-Squared calculated values, χ^2 exceeds the critical value of χ^2 thus providing a significant difference from the assumed expected frequencies of the observed numbers at each station. it was clear that none of the observations showed the equal distribution that was assumed from the expected observations. All the calculations eliminate the null hypothesis of an equal distribution due to the probability of equal observations recorded calculated at $P < 0.001$ for each day where observations took place except 27/08/2010 and 01/09/2010 where the probability was calculated to be <0.01.

The uneven distribution of *A. glaucogularis* may be down to factors both biotic and abiotic within the forest island. Due to time of year when the data was collected and the research period only

encompassing 5 simultaneous weeks, seasonal bias's may be present in the form of fruiting trees and breeding season. In order to reduce the discrepancies in the data, future data should be collected at varying times of the year over a number of years thus smoothing the effects of seasonality.

An interesting observation which to date has not been mentioned in any other work, became apparent over the study period. It was notable that there was a difference in departure time of *A. glaucogularis* and *A. ararauna*. From looking at the raw data a pattern developed where the majority of *A. glaucogularis* seemingly departed from the main forest island before *A. ararauna.* On many occasions *A. glaucogularis* left the main forest island approximately one hour prior to *A. ararauna*. This behaviour was especially apparent at station 1. Station 1 was a key position for observing intra-specific interactions and patterns in their daily migratory behaviour. Station 1 was located in close proximity to island 4 that was used in the forest island surveys. Island 4 was only approximately 413m away from the main forest island and was a key feature in the behavioural observations. The *Vochysia thyrsoidea* tree was distinctively utilised by *A. glaucogularis*inb the early evening. It was recognised that *A. glaucogularis* flew from the main island in pairs or small groups of 3 or 4 where some would briefly perch within island 4 where it appeared that individuals were flocking together. They would remain here until a large number would build up, with instances of up to 80 individuals being observed. It would be approximately after 1 hour that the flock would all leave together upon the emergence of *A. ararauna* from the main island and travel away in the same direction. Interestingly, *A. ararauna* did not utilised island 4 in the same manner nor in the same frequency as *A. glaucogularis*.

4.3 Behaviour

Previous studies by Yamashita *et al.* (1997) and according to there have been notable instances inter-specific competition between *A. glaucogularis* and *A. ararauna*. Most notably the behaviour recorded has been during the mating season where the behaviour was due to mate choice and territorial behaviour. This project was conducted during a non-mating season therefore such behaviours were not observed. However, many of the observations in both the point count surveys and island surveys recorded both species commonly flying in pairs. It is not possible though to distinguish the sexes of the species as both of them are not sexually dimorphic.

From reviewing previous literature on *A. glaucogularis* and *A. ararauna* there have never been instances recorded of the two species interacting mutually yet in this project several instances were recorded of the two species departing from the main islands within the same flocks and instances where drinking from the River Omi occurred in close proximity.

4.4 Population

According to Hesse *et al*. (2000) the populations recorded for the Blue-Throated Macaw have been extremely low and between 1993 and 1999 and by extrapolation of the data in relation to suitable habitat area it was calculated that the population was 120 individuals. With the data collected in this project it is not possible to extrapolate the data to give an estimation of the current population due to the unknown suitable currently in Bolivia. However, with respect to this paper from 2000 it possible that the population of *A. glaucogularis* has had a resurgence in the past 10 years due to the fact that the maximum number of individuals recorded in one day is 103 during this project. From this observation it is possible that the Barba Azul Nature Reserve holds approximately a third of the

current estimated population of *A. glaucogularis*, making the reserve a valuable environment for the conservation of this endemic species.

4.5 Future Development Proposed

The islands in which *A. glaucogularis* reside in at night are now known to be out with the perimeter of the Barba Azul Nature Reserve. Permissions need to be sought in order to explore 'Las Gamas' ranch to the north of the reserve, 'Los Patos' to the north- west, 'Pelotal' to the west and 'Juan Latino' to the east. With the purchase of the 'Juvena' ranch in September 2010 the prospects of further exploration of the Blue-Throated Macaws habitat can be performed allowing for a greater understanding of the current little known natural behaviour of this endemic species. From the research conducted in this project it was proven that on several occasions during the point count surveys flocks of *A. glaucogularis* travel depart from the main forest island toward 'Juvena' with the possibility of these flocks residing over night in this area. A more in depth understanding of *A. glaucogularis* will allow for more intricate and specific projects to be designed in order to preserve the current populations and empower the expanse of future populations.

Within the reserve, research into how *A. glaucogualris* utilises the gallery forest island in comparison to *A. ararauna* during the day needs to be explored further in relation to the idea proposed that some individuals reside in the main forest island over night when weather conditions deteriorate.

In accordance with Hesse *et al*. (2000) and the findings of Motacú palm nuts in the reserve, there is a notable difference in the method of consumption of the mesocarp layer of the Motacú palm nuts between *A. glaucogularis* and *A. ararauna*. In discovering the consumed fallen nuts within the forest it may be possible to discover whether feeding grounds are present, if these grounds are specific to a

species or are shared and the range of these grounds. In identifying from the fallen nuts the possible feeding areas it may be possible to gain a deeper understanding in the social and behavioural dynamics of *A. glaucogularis.*

5. Acknowledgements

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7. Development of Project

As a member of the University of Glasgow's 2010 Bolivia expedition to the Barba Azul Nature Reserve I was keen to explore further and put my interest into practice the behaviour and abundance of an endemic species. Based on work carried out by the University of Glasgow's 2009 expedition to Bolivia to the same region, a more in depth project was established by myself on the basis of the baseline work carried out on *A. glaucogularis* in 2009.

Previous surveys by Yashimata *et al*. (1997) and Hesse *et al*. (2000) on the Blue-Throated Macaw provided an informative baseline for the method of surveying this elusive species. It was known prior to the project that the natural behaviour of both *A. glaucogularis* and *A. ararauna* was to congregate on a large forest island during the day to feed and to roost on smaller forest islands away from main forest islands at night. The initial plan of the project was to only survey the incoming birds on the smaller forest islands at dusk with focus on how they utilised the islands for feeding and roosting as well as investigating inter and intra-specific behaviour observations. However it was soon realised that this was not an accurate nor reliable representation of the populations of *A. glaucogularis* and *A. ararauna* in the Barba Azul Nature Reserve as none of the islands were used as a roosting ground to any significance. Thus an additional method of point count surveys, was introduced based on a similar method being utilised in the baseline study of the reserve to allow for a more detailed snapshot of the population dynamics within the reserve. The island survey method continued throughout the project in order to collect additional behavioural data but it was not the primary method exploited to gather data on the abundance.

8. Appendices

Appendix 1: Chi-Squared Values for Blue-Throated Macaws on Point Count Surveys

Date	χ^2 value of the Total Number of Blue-Throated Macaw	P value of the χ^2 value of the Total Number of Blue-Throated Macaw
10/08/2010	17.03	<0.001
14/08/2010	44.91	<0.001
15/08/2010	126.65	<0.001
17/08/2010	119.1	<0.001
20/08/2010	17.34	<0.001
21/08/2010	152.9	<0.001
23/08/2010	38.28	<0.001
24/08/2010	25.34	<0.001
27/08/2010	10.74	<0.01
30/08/2010	42	<0.001
01/09/2010	10.16	<0.01
04/09/2010	144.98	<0.001

Appendix 2: Chi-Squared Value for Blue and Yellow Macaw on Point Count Surveys

Date	χ^2 value of the Total Number of Blue and Yellow Macaw	P value of the χ^2 value of the Total Number of Blue and Yellow Macaw
10/08/2010	77.59	<0.001
14/08/2010	56.48	<0.001
15/08/2010	19.01	<0.001
17/08/2010	13.75	<0.001
20/08/2010	17.88	<0.001
21/08/2010	0.97	>0.05
23/08/2010	56	<0.001
24/08/2010	21.66	<0.001
27/08/2010	82.77	<0.001
30/08/2010	35.01	<0.001
01/09/2010	35.01	<0.001
04/09/2010	150.36	<0.001

Appendix 3: Original Data for the Point Count Surveys

Date	Station	GPS	Time	No. Of Blue Throated Macaw	No. Of Blue and Yellow Macaw	Direction of Travel
10/08/2010	1	S13 44.793 W066 05.853	16:58	3	0	S
10/08/2010	1	S13 44.793 W066 05.853	17:07	5	0	N
10/08/2010	1	S13 44.793 W066 05.853	17:08	0	2	N
10/08/2010	1	S13 44.793 W066 05.853	17:13	0	3	NE
10/08/2010	1	S13 44.793 W066 05.853	17:15	0	3	NE
10/08/2010	1	S13 44.793 W066 05.853	17:31	3	7	NE
10/08/2010	1	S13 44.793 W066 05.853	17:32	3	0	NE
10/08/2010	1	S13 44.793 W066 05.853	17:32	0	4	NE
10/08/2010	1	S13 44.793 W066 05.853	17:34	0	2	NE
10/08/2010	1	S13 44.793 W066 05.853	17:53	0	18	NW
10/08/2010	1	S13 44.793 W066 05.853	17:55	0	2	NE
10/08/2010	1	S13 44.793 W066 05.853	17:56	4	0	N
10/08/2010	1	S13 44.793 W066 05.853	18:00	0	4	N
10/08/2010	1	S13 44.793 W066 05.853	18:03	0	3	NW
10/08/2010	1	S13 44.793 W066 05.853	18:07	0	2	N
10/08/2010	1	S13 44.793 W066 05.853	18:09	0	24	N
10/08/2010	1	S13 44.793 W066 05.853	18:13	0	13	NE
10/08/2010	1	S13 44.793 W066 05.853	18:15	0	2	NW
10/08/2010	1	S13 44.793 W066 05.853	18:20	0	2	NW
10/08/2010	2	S13 45.870 W066 06.900	16:57	3	0	E
10/08/2010	2	S13 45.870 W066 06.900	17:17	2	0	NNE
10/08/2010	2	S13 45.870 W066 06.900	17:31	0	1	N
10/08/2010	2	S13 45.870 W066 06.900	17:36	0	3	NNW
10/08/2010	2	S13 45.870 W066 06.900	18:01	2	0	N
10/08/2010	2	S13 45.870 W066 06.900	18:07	0	1	SE
10/08/2010	2	S13 45.870 W066 06.900	18:10	2	0	SSE
10/08/2010	2	S13 45.870 W066 06.900	18:25	2	0	E
10/08/2010	3	S13 45.491 W066 07.186	17:23	0	2	E
10/08/2010	3	S13 45.491 W066 07.186	17:38	0	4	W
10/08/2010	3	S13 45.491 W066 07.186	17:42	0	3	E
10/08/2010	3	S13 45.491 W066 07.186	17:48	0	15	N
10/08/2010	3	S13 45.491 W066 07.186	17:55	0	1	N
10/08/2010	3	S13 45.491 W066 07.186	17:57	0	4	N
10/08/2010	3	S13 45.491 W066 07.186	18:02	0	0	N
10/08/2010	3	S13 45.491 W066 07.186	18:17	0	0	N
10/08/2010	3	S13 45.491 W066 07.186	18:19	0	18	N
14/08/2010	1	S13 44.793 W066 05.853	16:52	0	4	N
14/08/2010	1	S13 44.793 W066 05.853	17:05	22	0	S
14/08/2010	1	S13 44.793 W066 05.853	17:12	3	0	NE
14/08/2010	1	S13 44.793 W066 05.853	17:13	0	2	S
14/08/2010	1	S13 44.793 W066 05.853	17:16	0	3	N
14/08/2010	1	S13 44.793 W066 05.853	17:17	0	3	N
14/08/2010	1	S13 44.793 W066 05.853	17:19	5	0	SW

Date	Station	GPS	Time	No. Of Blue Throated Macaw	No. Of Blue and Yellow Macaw	Direction of Travel
14/08/2010	1	S13 44.793 W066 05.853	17:20	6	0	NE
14/08/2010	1	S13 44.793 W066 05.853	17:26	0	5	NE
14/08/2010	1	S13 44.793 W066 05.853	17:28	0	2	N
14/08/2010	1	S13 44.793 W066 05.853	17:29	0	4	SE
14/08/2010	1	S13 44.793 W066 05.853	17:33	0	2	N
14/08/2010	1	S13 44.793 W066 05.853	17:33	0	3	S
14/08/2010	1	S13 44.793 W066 05.853	17:36	0	3	N
14/08/2010	1	S13 44.793 W066 05.853	17:37	0	6	N
14/08/2010	1	S13 44.793 W066 05.853	17:47	3	0	NE
14/08/2010	1	S13 44.793 W066 05.853	17:47	0	15	N
14/08/2010	1	S13 44.793 W066 05.853	17:49	0	6	NE
14/08/2010	1	S13 44.793 W066 05.853	18:03	0	10	NE
14/08/2010	1	S13 44.793 W066 05.853	18:19	0	1	S
14/08/2010	2	S13 45.870 W066 06.900	17:11	2	0	NE
14/08/2010	2	S13 45.870 W066 06.900	17:23	2	0	NW
14/08/2010	2	S13 45.870 W066 06.900	17:39	0	2	NW
14/08/2010	2	S13 45.870 W066 06.900	18:00	2	0	S
14/08/2010	3	S13 45.491 W066 07.186	16:51	0	4	NE
14/08/2010	3	S13 45.491 W066 07.186	17:03	0	6	SW
14/08/2010	3	S13 45.491 W066 07.186	17:06	0	8	E
14/08/2010	3	S13 45.491 W066 07.186	17:14	5	0	N
14/08/2010	3	S13 45.491 W066 07.186	17:18	0	2	E
14/08/2010	3	S13 45.491 W066 07.186	17:19	0	2	E
14/08/2010	3	S13 45.491 W066 07.186	17:32	0	6	NE
14/08/2010	3	S13 45.491 W066 07.186	17:32	0	4	E
14/08/2010	3	S13 45.491 W066 07.186	17:34	0	2	NE
14/08/2010	3	S13 45.491 W066 07.186	17:40	0	5	NE
14/08/2010	3	S13 45.491 W066 07.186	17:43	0	6	E
14/08/2010	3	S13 45.491 W066 07.186	17:44	0	1	SW
14/08/2010	3	S13 45.491 W066 07.186	17:46	0	3	E
14/08/2010	3	S13 45.491 W066 07.186	17:50	0	8	NE
14/08/2010	3	S13 45.491 W066 07.186	17:56	0	1	SW
14/08/2010	3	S13 45.491 W066 07.186	17:58	0	2	E
14/08/2010	3	S13 45.491 W066 07.186	18:01	0	3	E
14/08/2010	3	S13 45.491 W066 07.186	18:18	0	2	NE
15/08/2010	1	S13 44.793 W066 05.853	16:51	14	0	SE
15/08/2010	1	S13 44.793 W066 05.853	16:53	2	0	E
15/08/2010	1	S13 44.793 W066 05.853	16:54	6	0	NE
15/08/2010	1	S13 44.793 W066 05.853	16:56	2	0	N
15/08/2010	1	S13 44.793 W066 05.853	16:56	4	0	NE
15/08/2010	1	S13 44.793 W066 05.853	16:57	11	0	NE
15/08/2010	1	S13 44.793 W066 05.853	16:58	2	0	NE
15/08/2010	1	S13 44.793 W066 05.853	17:00	13	0	NE
15/08/2010	1	S13 44.793 W066 05.853	17:03	4	0	NE
15/08/2010	1	S13 44.793 W066 05.853	17:08	0	1	NE
15/08/2010	1	S13 44.793 W066 05.853	17:14	0	4	NW
15/08/2010	1	S13 44.793 W066 05.853	17:18	0	2	E

Date	Station	GPS	Time	No. Of Blue Throated Macaw	No. Of Blue and Yellow Macaw	Direction of Travel
15/08/2010	1	S13 44.793 W066 05.853	17:19	0	2	NE
15/08/2010	1	S13 44.793 W066 05.853	17:22	0	2	N
15/08/2010	1	S13 44.793 W066 05.853	17:22	8	0	N
15/08/2010	1	S13 44.793 W066 05.853	17:23	0	5	N
15/08/2010	1	S13 44.793 W066 05.853	17:24	0	4	N
15/08/2010	1	S13 44.793 W066 05.853	17:25	0	1	S
15/08/2010	1	S13 44.793 W066 05.853	17:30	2	1	S
15/08/2010	1	S13 44.793 W066 05.853	17:31	0	5	N
15/08/2010	1	S13 44.793 W066 05.853	17:31	0	8	N
15/08/2010	1	S13 44.793 W066 05.853	17:32	0	3	E
15/08/2010	1	S13 44.793 W066 05.853	17:36	2	0	N
15/08/2010	1	S13 44.793 W066 05.853	17:38	4	0	N
15/08/2010	1	S13 44.793 W066 05.853	17:39	0	3	N
15/08/2010	1	S13 44.793 W066 05.853	17:39	2	0	S
15/08/2010	1	S13 44.793 W066 05.853	17:40	0	1	N
15/08/2010	1	S13 44.793 W066 05.853	17:44	0	3	E
15/08/2010	1	S13 44.793 W066 05.853	17:47	0	6	N
15/08/2010	1	S13 44.793 W066 05.853	17:56	0	3	E
15/08/2010	1	S13 44.793 W066 05.853	18:02	0	4	N
15/08/2010	1	S13 44.793 W066 05.853	18:04	0	8	N
15/08/2010	1	S13 44.793 W066 05.853	18:07	0	7	N
15/08/2010	1	S13 44.793 W066 05.853	18:14	0	3	NW
15/08/2010	1	S13 44.793 W066 05.853	18:17	0	3	NW
15/08/2010	2	S13 45.870 W066 06.900	17:09	0	3	N
15/08/2010	2	S13 45.870 W066 06.900	17:12	1	0	N
15/08/2010	2	S13 45.870 W066 06.900	17:13	0	2	W
15/08/2010	2	S13 45.870 W066 06.900	17:16	0	1	S
15/08/2010	2	S13 45.870 W066 06.900	17:24	0	4	W
15/08/2010	2	S13 45.870 W066 06.900	17:33	0	9	N
15/08/2010	2	S13 45.870 W066 06.900	17:39	0	9	N
15/08/2010	2	S13 45.870 W066 06.900	17:45	0	4	N
15/08/2010	2	S13 45.870 W066 06.900	17:45	3	0	N
15/08/2010	2	S13 45.870 W066 06.900	17:46	0	2	N
15/08/2010	2	S13 45.870 W066 06.900	17:52	0	2	W
15/08/2010	2	S13 45.870 W066 06.900	18:00	0	2	N
15/08/2010	2	S13 45.870 W066 06.900	18:05	0	2	N
15/08/2010	2	S13 45.870 W066 06.900	18:17	0	6	N
15/08/2010	2	S13 45.870 W066 06.900	18:18	0	3	N
15/08/2010	3	S13 45.491 W066 07.186	17:07	0	6	E
15/08/2010	3	S13 45.491 W066 07.186	17:15	3	0	SE
15/08/2010	3	S13 45.491 W066 07.186	17:26	0	2	E
15/08/2010	3	S13 45.491 W066 07.186	17:27	0	4	E
15/08/2010	3	S13 45.491 W066 07.186	17:34	0	2	E
15/08/2010	3	S13 45.491 W066 07.186	17:34	0	5	N
15/08/2010	3	S13 45.491 W066 07.186	17:38	0	13	N
15/08/2010	3	S13 45.491 W066 07.186	17:40	0	5	N
15/08/2010	3	S13 45.491 W066 07.186	17:41	0	4	NE

Date	Station	GPS	Time	No. Of Blue Throated Macaw	No. Of Blue and Yellow Macaw	Direction of Travel
15/08/2010	3	S13 45.491 W066 07.186	17:44	0	2	E
15/08/2010	3	S13 45.491 W066 07.186	17:45	0	26	N
15/08/2010	3	S13 45.491 W066 07.186	17:50	0	2	S
15/08/2010	3	S13 45.491 W066 07.186	18:00	0	32	NE
17/08/2010	1	S13 44.793 W066 05.853	16:59	0	2	E
17/08/2010	1	S13 44.793 W066 05.853	17:01	1	0	N
17/08/2010	1	S13 44.793 W066 05.853	17:23	47	0	N
17/08/2010	1	S13 44.793 W066 05.853	17:24	7	0	NE
17/08/2010	1	S13 44.793 W066 05.853	17:25	5	0	SW
17/08/2010	1	S13 44.793 W066 05.853	17:27	4	0	S
17/08/2010	1	S13 44.793 W066 05.853	17:27	3	0	S
17/08/2010	1	S13 44.793 W066 05.853	17:33	2	0	NE
17/08/2010	1	S13 44.793 W066 05.853	17:41	6	0	N
17/08/2010	1	S13 44.793 W066 05.853	17:41	1	0	E
17/08/2010	1	S13 44.793 W066 05.853	17:46	0	17	N
17/08/2010	1	S13 44.793 W066 05.853	17:46	0	2	NE
17/08/2010	1	S13 44.793 W066 05.853	17:47	4	0	N
17/08/2010	1	S13 44.793 W066 05.853	17:47	0	2	NE
17/08/2010	1	S13 44.793 W066 05.853	17:47	0	1	N
17/08/2010	1	S13 44.793 W066 05.853	17:48	0	2	N
17/08/2010	1	S13 44.793 W066 05.853	17:48	0	16	N
17/08/2010	1	S13 44.793 W066 05.853	18:00	0	3	NE
17/08/2010	1	S13 44.793 W066 05.853	18:00	0	1	E
17/08/2010	1	S13 44.793 W066 05.853	18:11	0	2	W
17/08/2010	2	S13 45.870 W066 06.900	17:05	3	0	N
17/08/2010	2	S13 45.870 W066 06.900	17:06	2	0	N
17/08/2010	2	S13 45.870 W066 06.900	17:11	2	0	N
17/08/2010	2	S13 45.870 W066 06.900	17:20	0	8	NE
17/08/2010	2	S13 45.870 W066 06.900	17:36	0	10	S
17/08/2010	2	S13 45.870 W066 06.900	17:37	0	6	NE
17/08/2010	2	S13 45.870 W066 06.900	17:56	0	15	N
17/08/2010	2	S13 45.870 W066 06.900	18:05	0	2	S
17/08/2010	2	S13 45.870 W066 06.900	18:20	0	4	W
17/08/2010	3	S13 45.297 W066 06.800	16:45	0	30	SW
17/08/2010	3	S13 45.297 W066 06.800	16:50	0	3	SW
17/08/2010	3	S13 45.297 W066 06.800	17:40	0	28	NE
17/08/2010	3	S13 45.297 W066 06.800	17:45	3	0	SW
17/08/2010	3	S13 45.297 W066 06.800	17:48	0	20	SE
17/08/2010	3	S13 45.297 W066 06.800	18:31	2	0	N
20/08/2010	1	S13 44.793 W066 05.853	17:23	2	0	SE
20/08/2010	1	S13 44.793 W066 05.853	17:33	0	1	S
20/08/2010	1	S13 44.793 W066 05.853	17:37	0	2	N
20/08/2010	1	S13 44.793 W066 05.853	17:38	0	2	SE
20/08/2010	1	S13 44.793 W066 05.853	17:45	0	3	SE
20/08/2010	1	S13 44.793 W066 05.853	17:45	0	2	SE
20/08/2010	1	S13 44.793 W066 05.853	17:46	0	4	N
20/08/2010	1	S13 44.793 W066 05.853	17:46	2	0	N

Date	Station	GPS	Time	No. Of Blue Throated Macaw	No. Of Blue and Yellow Macaw	Direction of Travel
20/08/2010	1	S13 44.793 W066 05.853	17:46	2	0	SE
20/08/2010	1	S13 44.793 W066 05.853	17:49	2	0	SE
20/08/2010	1	S13 44.793 W066 05.853	17:51	0	3	N
20/08/2010	1	S13 44.793 W066 05.853	17:57	2	0	SE
20/08/2010	1	S13 44.793 W066 05.853	17:57	0	2	N
20/08/2010	1	S13 44.793 W066 05.853	17:58	0	2	N
20/08/2010	1	S13 44.793 W066 05.853	17:59	2	2	SE
20/08/2010	1	S13 44.793 W066 05.853	18:00	0	2	SE
20/08/2010	1	S13 44.793 W066 05.853	18:00	0	2	SE
20/08/2010	1	S13 44.793 W066 05.853	18:04	2	0	N
20/08/2010	1	S13 44.793 W066 05.853	18:05	0	3	NE
20/08/2010	1	S13 44.793 W066 05.853	18:05	0	2	NW
20/08/2010	1	S13 44.793 W066 05.853	18:11	0	2	NE
20/08/2010	1	S13 44.793 W066 05.853	18:14	0	4	N
20/08/2010	2	S13 45.870 W066 06.900	18:22	0	12	N
20/08/2010	3	S13 45.297 W066 06.800	17:14	2	0	SW
20/08/2010	3	S13 45.297 W066 06.800	17:27	0	2	E
20/08/2010	3	S13 45.297 W066 06.800	17:32	2	0	SW
20/08/2010	3	S13 45.297 W066 06.800	17:37	0	17	E
20/08/2010	3	S13 45.297 W066 06.800	17:48	0	3	E
20/08/2010	3	S13 45.297 W066 06.800	17:57	0	2	N
20/08/2010	3	S13 45.297 W066 06.800	17:58	0	10	N
20/08/2010	3	S13 45.297 W066 06.800	18:07	0	2	E
20/08/2010	3	S13 45.297 W066 06.800	18:09	0	2	N
20/08/2010	3	S13 45.297 W066 06.800	18:11	0	5	E
21/08/2010	1	S13 44.793 W066 05.853	16:44	4	0	N
21/08/2010	1	S13 44.793 W066 05.853	16:58	3	0	N
21/08/2010	1	S13 44.793 W066 05.853	16:59	1	0	N
21/08/2010	1	S13 44.793 W066 05.853	17:08	11	0	S
21/08/2010	1	S13 44.793 W066 05.853	17:08	8	0	E
21/08/2010	1	S13 44.793 W066 05.853	17:20	4	0	E
21/08/2010	1	S13 44.793 W066 05.853	17:26	1	0	E
21/08/2010	1	S13 44.793 W066 05.853	17:44	0	3	N
21/08/2010	1	S13 44.793 W066 05.853	17:45	0	1	N
21/08/2010	1	S13 44.793 W066 05.853	17:52	2	0	N
21/08/2010	1	S13 44.793 W066 05.853	18:08	0	3	N
21/08/2010	1	S13 44.793 W066 05.853	18:09	0	6	N
21/08/2010	1	S13 44.793 W066 05.853	18:09	0	2	N
21/08/2010	1	S13 44.793 W066 05.853	18:10	0	17	N
21/08/2010	1	S13 44.793 W066 05.853	18:10	0	2	NE
21/08/2010	1	S13 44.793 W066 05.853	18:12	0	5	N
21/08/2010	1	S13 44.793 W066 05.853	18:12	0	2	E
21/08/2010	1	S13 44.793 W066 05.853	18:14	0	2	NE
21/08/2010	1	S13 44.793 W066 05.853	18:14	0	2	NE
21/08/2010	1	S13 44.793 W066 05.853	18:17	0	2	N
21/08/2010	1	S13 44.793 W066 05.853	18:23	0	2	N
21/08/2010	1	S13 44.793 W066 05.853	18:24	0	3	N

Date	Station	GPS	Time	No. Of Blue Throated Macaw	No. Of Blue and Yellow Macaw	Direction of Travel
21/08/2010	1	S13 44.793 W066 05.853	18:26	0	2	W
21/08/2010	1	S13 44.793 W066 05.853	18:26	0	2	W
21/08/2010	1	S13 44.793 W066 05.853	18:28	0	5	N
21/08/2010	1	S13 44.793 W066 05.853	18:28	0	3	N
21/08/2010	2	S13 45.870 W066 06.900	17:01	0	2	S
21/08/2010	2	S13 45.870 W066 06.900	17:13	0	7	W
21/08/2010	2	S13 45.870 W066 06.900	17:21	0	2	E
21/08/2010	2	S13 45.870 W066 06.900	17:26	0	6	N
21/08/2010	2	S13 45.870 W066 06.900	17:28	0	4	N
21/08/2010	2	S13 45.870 W066 06.900	17:30	0	2	N
21/08/2010	2	S13 45.870 W066 06.900	17:37	0	3	E
21/08/2010	2	S13 45.870 W066 06.900	17:41	0	4	E
21/08/2010	2	S13 45.870 W066 06.900	17:54	0	6	N
21/08/2010	2	S13 45.870 W066 06.900	17:54	0	2	E
21/08/2010	2	S13 45.870 W066 06.900	17:56	0	2	S
21/08/2010	2	S13 45.870 W066 06.900	18:06	0	2	N
21/08/2010	2	S13 45.870 W066 06.900	18:08	0	2	E
21/08/2010	2	S13 45.870 W066 06.900	18:14	0	14	N
21/08/2010	3	S13 45.297 W066 06.800	17:02	0	5	E
21/08/2010	3	S13 45.297 W066 06.800	17:03	0	2	E
21/08/2010	3	S13 45.297 W066 06.800	17:08	0	3	E
21/08/2010	3	S13 45.297 W066 06.800	17:27	0	2	E
21/08/2010	3	S13 45.297 W066 06.800	17:35	0	0	E
21/08/2010	3	S13 45.297 W066 06.800	17:50	0	3	NE
21/08/2010	3	S13 45.297 W066 06.800	17:54	0	6	E
21/08/2010	3	S13 45.297 W066 06.800	18:05	0	2	NE
21/08/2010	3	S13 45.297 W066 06.800	18:07	0	2	NE
21/08/2010	3	S13 45.297 W066 06.800	18:07	0	4	E
21/08/2010	3	S13 45.297 W066 06.800	18:12	0	6	N
21/08/2010	3	S13 45.297 W066 06.800	18:13	0	10	NE
21/08/2010	3	S13 45.297 W066 06.800	18:13	0	10	NW
21/08/2010	3	S13 45.297 W066 06.800	18:14	0	2	NE
21/08/2010	3	S13 45.297 W066 06.800	18:17	0	5	N
21/08/2010	3	S13 45.297 W066 06.800	18:25	0	2	E
21/08/2010	3	S13 45.297 W066 06.800	18:29	0	5	N
23/08/2010	1	S13 44.793 W066 05.853	16:42	3	0	N
23/08/2010	1	S13 44.793 W066 05.853	16:55	1	0	N
23/08/2010	1	S13 44.793 W066 05.853	16:56	10	0	N
23/08/2010	1	S13 44.793 W066 05.853	16:56	2	0	N
23/08/2010	1	S13 44.793 W066 05.853	17:03	1	0	N
23/08/2010	1	S13 44.793 W066 05.853	17:06	2	0	N
23/08/2010	1	S13 44.793 W066 05.853	17:11	2	0	N
23/08/2010	1	S13 44.793 W066 05.853	17:12	6	0	N
23/08/2010	1	S13 44.793 W066 05.853	17:38	3	0	E
23/08/2010	1	S13 44.793 W066 05.853	17:40	2	0	N
23/08/2010	1	S13 44.793 W066 05.853	17:55	0	1	N
23/08/2010	1	S13 44.793 W066 05.853	17:55	0	3	N

Date	Station	GPS	Time	No. Of Blue Throated Macaw	No. Of Blue and Yellow Macaw	Direction of Travel
23/08/2010	1	S13 44.793 W066 05.853	17:56	0	3	N
23/08/2010	1	S13 44.793 W066 05.853	17:56	0	4	N
23/08/2010	1	S13 44.793 W066 05.853	17:59	0	2	N
23/08/2010	1	S13 44.793 W066 05.853	18:02	0	3	N
23/08/2010	1	S13 44.793 W066 05.853	18:02	0	4	N
23/08/2010	1	S13 44.793 W066 05.853	18:03	0	2	N
23/08/2010	1	S13 44.793 W066 05.853	18:03	0	2	N
23/08/2010	1	S13 44.793 W066 05.853	18:03	0	3	E
23/08/2010	1	S13 44.793 W066 05.853	18:03	0	2	N
23/08/2010	1	S13 44.793 W066 05.853	18:08	0	2	N
23/08/2010	1	S13 44.793 W066 05.853	18:11	0	18	E
23/08/2010	1	S13 44.793 W066 05.853	18:19	0	4	N
23/08/2010	1	S13 44.793 W066 05.853	18:20	0	8	N
23/08/2010	1	S13 44.793 W066 05.853	18:21	0	5	N
23/08/2010	1	S13 44.793 W066 05.853	18:23	0	6	N
23/08/2010	2	S13 45.870 W066 06.900	17:08	0	3	E
23/08/2010	2	S13 45.870 W066 06.900	17:09	0	2	NE
23/08/2010	2	S13 45.870 W066 06.900	17:14	0	4	NE
23/08/2010	2	S13 45.870 W066 06.900	17:24	0	4	N
23/08/2010	2	S13 45.870 W066 06.900	17:25	0	6	NW
23/08/2010	2	S13 45.870 W066 06.900	17:29	0	4	NE
23/08/2010	2	S13 45.870 W066 06.900	17:30	0	2	NE
23/08/2010	2	S13 45.870 W066 06.900	17:34	0	2	NE
23/08/2010	2	S13 45.870 W066 06.900	17:41	0	12	NE
23/08/2010	2	S13 45.870 W066 06.900	17:42	0	3	SW
23/08/2010	2	S13 45.870 W066 06.900	17:47	0	2	NE
23/08/2010	2	S13 45.870 W066 06.900	17:53	0	2	SW
23/08/2010	2	S13 45.870 W066 06.900	17:57	0	1	SW
23/08/2010	2	S13 45.870 W066 06.900	17:59	0	3	E
23/08/2010	2	S13 45.870 W066 06.900	18:01	0	8	NE
23/08/2010	2	S13 45.870 W066 06.900	18:03	0	2	NE
23/08/2010	2	S13 45.870 W066 06.900	18:06	0	3	NE
23/08/2010	2	S13 45.870 W066 06.900	18:10	0	3	E
23/08/2010	2	S13 45.870 W066 06.900	18:12	0	7	NE
23/08/2010	2	S13 45.870 W066 06.900	18:16	0	3	NE
23/08/2010	3	S13 45.297 W066 06.800	17:45	4	0	N
23/08/2010	3	S13 45.297 W066 06.800	18:05	6	0	N
23/08/2010	3	S13 45.297 W066 06.800	18:05	0	3	NE
23/08/2010	3	S13 45.297 W066 06.800	18:10	0	2	NE
23/08/2010	3	S13 45.297 W066 06.800	18:19	0	3	N
24/08/2010	1	S13 44.793 W066 05.853	17:14	0	8	NE
24/08/2010	1	S13 44.793 W066 05.853	17:27	0	8	NE
24/08/2010	1	S13 44.793 W066 05.853	17:36	0	11	NE
24/08/2010	1	S13 44.793 W066 05.853	17:51	0	4	SE
24/08/2010	1	S13 44.793 W066 05.853	18:12	0	2	NE
24/08/2010	1	S13 44.793 W066 05.853	18:14	0	2	N
24/08/2010	1	S13 44.793 W066 05.853	18:16	0	3	SE

Date	Station	GPS	Time	No. Of Blue Throated Macaw	No. Of Blue and Yellow Macaw	Direction of Travel
24/08/2010	1	S13 44.793 W066 05.853	18:17	0	3	NW
24/08/2010	1	S13 44.793 W066 05.853	18:20	2	0	N
24/08/2010	2	S13 45.870 W066 06.900	17:18	0	5	E
24/08/2010	2	S13 45.870 W066 06.900	17:21	0	10	N
24/08/2010	2	S13 45.870 W066 06.900	17:41	6	0	N
24/08/2010	2	S13 45.870 W066 06.900	17:44	0	2	N
24/08/2010	2	S13 45.870 W066 06.900	17:48	6	0	N
24/08/2010	2	S13 45.870 W066 06.900	17:48	0	2	E
24/08/2010	2	S13 45.870 W066 06.900	17:51	0	2	N
24/08/2010	2	S13 45.870 W066 06.900	17:51	0	3	S
24/08/2010	2	S13 45.870 W066 06.900	17:59	2	0	N
24/08/2010	2	S13 45.870 W066 06.900	18:00	2	0	N
24/08/2010	2	S13 45.870 W066 06.900	18:01	0	4	N
24/08/2010	2	S13 45.870 W066 06.900	18:04	0	2	N
24/08/2010	2	S13 45.870 W066 06.900	18:10	0	11	N
24/08/2010	2	S13 45.870 W066 06.900	18:12	0	5	N
24/08/2010	3	S13 45.297 W066 06.800	18:08	0	21	NE
24/08/2010	3	S13 45.297 W066 06.800	18:11	0	2	NE
24/08/2010	3	S13 45.297 W066 06.800	18:15	0	2	NE
24/08/2010	3	S13 45.297 W066 06.800	18:15	0	10	N
24/08/2010	3	S13 45.297 W066 06.800	18:16	0	18	NE
24/08/2010	3	S13 45.297 W066 06.800	18:16	0	3	NE
24/08/2010	3	S13 45.297 W066 06.800	18:17	0	2	E
24/08/2010	3	S13 45.297 W066 06.800	18:18	0	3	E
24/08/2010	3	S13 45.297 W066 06.800	18:19	0	2	NE
24/08/2010	3	S13 45.297 W066 06.800	18:21	0	5	NE
24/08/2010	3	S13 45.297 W066 06.800	18:22	0	3	W
24/08/2010	3	S13 45.297 W066 06.800	18:23	0	4	NE
24/08/2010	3	S13 45.297 W066 06.800	18:24	0	2	N
27/08/2010	1	S13 44.793 W066 05.853	17:07	0	11	N
27/08/2010	1	S13 44.793 W066 05.853	17:09	0	4	N
27/08/2010	1	S13 44.793 W066 05.853	17:13	0	15	N
27/08/2010	1	S13 44.793 W066 05.853	17:13	0	6	N
27/08/2010	1	S13 44.793 W066 05.853	17:22	0	0	0
27/08/2010	1	S13 44.793 W066 05.853	17:22	0	1	E
27/08/2010	1	S13 44.793 W066 05.853	17:32	0	0	SW
27/08/2010	1	S13 44.793 W066 05.853	17_46	0	4	N
27/08/2010	1	S13 44.793 W066 05.853	17:50	0	2	NE
27/08/2010	1	S13 44.793 W066 05.853	17:51	0	3	E
27/08/2010	1	S13 44.793 W066 05.853	17:54	0	24	N
27/08/2010	1	S13 44.793 W066 05.853	17:55	0	2	N
27/08/2010	1	S13 44.793 W066 05.853	17:58	0	2	NW
27/08/2010	1	S13 44.793 W066 05.853	18:04	0	2	NW
27/08/2010	1	S13 44.793 W066 05.853	18:05	0	4	0
27/08/2010	2	S13 45.870 W066 06.900	17:08	0	2	N
27/08/2010	2	S13 45.870 W066 06.900	17:35	0	2	E
27/08/2010	2	S13 45.870 W066 06.900	17:55	0	4	S

Date	Station	GPS	Time	No. Of Blue Throated Macaw	No. Of Blue and Yellow Macaw	Direction of Travel
27/08/2010	2	S13 45.870 W066 06.900	17:55	0	4	E
27/08/2010	3	S13 45.297 W066 06.800	17:00	2	0	N
27/08/2010	3	S13 45.297 W066 06.800	17:30	14	0	N
27/08/2010	3	S13 45.297 W066 06.800	17:56	0	9	E
27/08/2010	3	S13 45.297 W066 06.800	17:56	0	5	E
27/08/2010	3	S13 45.297 W066 06.800	17:57	0	1	E
30/08/2010	1	S13 44.793 W066 05.853	16:56	3	0	NE
30/08/2010	1	S13 44.793 W066 05.853	17:10	0	2	NE
30/08/2010	1	S13 44.793 W066 05.853	17:25	8	14	NE
30/08/2010	1	S13 44.793 W066 05.853	17:25	2	0	SSW
30/08/2010	1	S13 44.793 W066 05.853	17:30	4	0	NW
30/08/2010	1	S13 44.793 W066 05.853	17:30	0	3	NW
30/08/2010	1	S13 44.793 W066 05.853	17:32	0	3	SSE
30/08/2010	1	S13 44.793 W066 05.853	17:32	0	3	NE
30/08/2010	1	S13 44.793 W066 05.853	17:32	0	3	ENE
30/08/2010	1	S13 44.793 W066 05.853	17:41	0	2	NE
30/08/2010	1	S13 44.793 W066 05.853	17:41	4	0	NE
30/08/2010	2	S13 45.870 W066 06.900	00:00	0	0	0
30/08/2010	3	S13 45.297 W066 06.800	17:27	0	3	W-E
30/08/2010	3	S13 45.297 W066 06.800	17:34	0	2	E
30/08/2010	3	S13 45.297 W066 06.800	17:55	0	3	NE
30/08/2010	3	S13 45.297 W066 06.800	18:01	0	2	NE
01/09/2010	1	S13 44.793 W066 05.853	17:18	0	1	W
01/09/2010	1	S13 44.793 W066 05.853	17:23	0	2	N
01/09/2010	1	S13 44.793 W066 05.853	17:24	0	3	W
01/09/2010	1	S13 44.793 W066 05.853	17:25	0	8	0
01/09/2010	1	S13 44.793 W066 05.853	17:29	0	3	W
01/09/2010	1	S13 44.793 W066 05.853	17:30	0	3	W
01/09/2010	1	S13 44.793 W066 05.853	17:32	0	4	W
01/09/2010	1	S13 44.793 W066 05.853	17:33	2	9	N
01/09/2010	1	S13 44.793 W066 05.853	17:49	0	3	N
01/09/2010	1	S13 44.793 W066 05.853	17:49	0	3	N
01/09/2010	1	S13 44.793 W066 05.853	17:51	0	3	N
01/09/2010	1	S13 44.793 W066 05.853	17:52	0	2	N
01/09/2010	1	S13 44.793 W066 05.853	17:54	0	12	N
01/09/2010	1	S13 44.793 W066 05.853	17:54	0	2	W
01/09/2010	1	S13 44.793 W066 05.853	18:00	0	12	N
01/09/2010	1	S13 44.793 W066 05.853	18:01	0	8	N
01/09/2010	1	S13 44.793 W066 05.853	18:06	0	17	N
01/09/2010	1	S13 44.793 W066 05.853	18:08	0	6	N
01/09/2010	1	S13 44.793 W066 05.853	18:08	0	7	N
01/09/2010	1	S13 44.793 W066 05.853	18:09	0	5	N
01/09/2010	1	S13 44.793 W066 05.853	18:11	0	10	N
01/09/2010	1	S13 44.793 W066 05.853	18:12	0	3	N
01/09/2010	2	S13 45.870 W066 06.900	17:14	3	0	N
01/09/2010	2	S13 45.870 W066 06.900	17:16	0	3	N
01/09/2010	2	S13 45.870 W066 06.900	17:25	2	0	N

Date	Station	GPS	Time	No. Of Blue Throated Macaw	No. Of Blue and Yellow Macaw	Direction of Travel
01/09/2010	2	S13 45.870 W066 06.900	17:50	3	0	N
01/09/2010	2	S13 45.870 W066 06.900	18:05	0	1	E
01/09/2010	2	S13 45.870 W066 06.900	18:10	0	7	E
01/09/2010	2	S13 45.870 W066 06.900	18:11	0	6	N
01/09/2010	2	S13 45.870 W066 06.900	18:18	0	5	N
01/09/2010	2	S13 45.870 W066 06.900	18:26	0	2	W
01/09/2010	3	S13 45.297 W066 06.800	17:04	2	0	SSE
01/09/2010	3	S13 45.297 W066 06.800	17:42	0	3	SE
01/09/2010	3	S13 45.297 W066 06.800	17:47	0	3	SSE
01/09/2010	3	S13 45.297 W066 06.800	17:47	5	0	SSE
01/09/2010	3	S13 45.297 W066 06.800	17:47	0	2	SSE
01/09/2010	3	S13 45.297 W066 06.800	17:55	2	0	SSE
01/09/2010	3	S13 45.297 W066 06.800	18:11	0	2	E
01/09/2010	3	S13 45.297 W066 06.800	18:13	3	0	E
01/09/2010	3	S13 45.297 W066 06.800	18:13	3	0	E
04/09/2010	1	S13 44.793 W066 05.853	17:04	0	3	N
04/09/2010	1	S13 44.793 W066 05.853	17:08	0	29	N
04/09/2010	1	S13 44.793 W066 05.853	17:10	0	12	N
04/09/2010	1	S13 44.793 W066 05.853	17:21	0	3	NE
04/09/2010	1	S13 44.793 W066 05.853	17:31	0	26	N
04/09/2010	1	S13 44.793 W066 05.853	17:41	0	2	N
04/09/2010	1	S13 44.793 W066 05.853	17:53	0	2	N
04/09/2010	2	S13 45.870 W066 06.900	17:58	2	0	S
04/09/2010	3	S13 45.297 W066 06.800	16:49	15	0	W
04/09/2010	3	S13 45.297 W066 06.800	17:00	0	2	E
04/09/2010	3	S13 45.297 W066 06.800	17:03	0	2	W
04/09/2010	3	S13 45.297 W066 06.800	17:05	0	2	E
04/09/2010	3	S13 45.297 W066 06.800	17:08	58	0	E
04/09/2010	3	S13 45.297 W066 06.800	17:11	0	2	W
04/09/2010	3	S13 45.297 W066 06.800	17:12	0	2	W
04/09/2010	3	S13 45.297 W066 06.800	17:15	1	0	W
04/09/2010	3	S13 45.297 W066 06.800	17:16	0	4	E
04/09/2010	3	S13 45.297 W066 06.800	17:18	1	0	W
04/09/2010	3	S13 45.297 W066 06.800	17:29	1	0	E
04/09/2010	3	S13 45.297 W066 06.800	17:32	24	0	E
04/09/2010	3	S13 45.297 W066 06.800	17:32	1	0	W
04/09/2010	3	S13 45.297 W066 06.800	17:36	0	1	W
04/09/2010	3	S13 45.297 W066 06.800	17:36	0	2	E
04/09/2010	3	S13 45.297 W066 06.800	17:36	0	3	W
04/09/2010	3	S13 45.297 W066 06.800	17:37	0	4	NE
04/09/2010	3	S13 45.297 W066 06.800	17:41	0	4	E
04/09/2010	3	S13 45.297 W066 06.800	17:49	0	2	W
04/09/2010	3	S13 45.297 W066 06.800	17:52	0	1	W
04/09/2010	3	S13 45.297 W066 06.800	17:52	0	1	W
04/09/2010	3	S13 45.297 W066 06.800	17:55	0	2	SW
04/09/2010	3	S13 45.297 W066 06.800	18:00	0	3	N
04/09/2010	3	S13 45.297 W066 06.800	18:01	0	3	N

Appendix 4: Original Data for the Island Surveys

Date	Island	Names	Weather	Total No. Of Flocks	Total No. Of Individuals	No. Of Blue-Throated Macaws	No. Of Blue and Yellow Macaws	Ratio of Adults:Juveniles	Distribution	Tiered Position of BT Macaws	Tiered Position of BY Macaws	No of Trees Marked for Roosting	No. Of Trees Marked for Feeding	Dominant Species	Fruiting Trees	Other Observations
02/08/2010	1	Alwyn and Gwynedd	Hot and Dry	0	0	0	0	0	0	0	0	0	0	N/A	No	
03/08/2010	2	Jo and Alwyn	Hot and Dry	11	53	0	53	0	Random	0	Emergent	0	0	BY	No	17:20 9 BT Macaws flew N
																18:06 11 BT Macaws flew N
04/08/2010	3	Lydia, Jo and Chris	Cold and Dry	0	0	0	0	0	0	0	0	0	0	N/A	No	16:45 2 BT Macaws flew E
																16:53 3 BT Macaws flew W
																17:27 4 BT Macaws flew SW
																17:45 3 BT Macaws flew E from island 4
																18:03 2 BT Macaws flew SW
05/08/2010	4	Lydia and Miguel	Hot and Dry	6	57	6	51	0	Clustered	Canopy	Canopy	0	0	BY	No	16:55 >15 BY Macaws flew SW
																17:06 5 BY Macaws circle then leave
																17:21 3 BT Macaws flew SE
																17:40 10 BT Macaws flew E
																17:51 2 BT Macaws flew NE
																17:54 2 BT Mawcas flew NE
																18:03 2 BY Macaws circle

Date	Island	Names	Weather	Total No. Of Flocks	Total No. Of Individuals	No. Of Blue-Throated Macaws	No. Of Blue and Yellow Macaws	Ratio of Adults:Juveniles	Distribution	Tiered Position of BT Macaws	Tiered Position of BY Macaws	No of Trees Marked for Roosting	No. Of Trees Marked for Feeding	Dominant Species	Fruiting Trees	Other Observations
																18:06 5 BT Macaws flew N
06/08/2010	5	Alwyn and Miguel	Hot and Dry	1	4	0	4	0	Clustered	0	Emergent	0	0	BY	No	18:10 4 BT Macaws flew N
																18:22 6 BT Macaws flew N
																18:35 4 BY Macaws from island to the left
07/08/2010	6	Alwyn and Miguel	Hot and Dry	1	5	5	0	0	Clustered	Emergent	Emergent	0	0	BY	No	17:35 2 BY Macaws flew N
																18:20 2 BT Macaws flew over island N
09/08/2010	1	Lydia, Kirsty and Alwyn	Hot and Dry	1	2	0	2	0	Clustered		Canopy	0	0	BY	No	17:05 2 BY Macaws flew SE
																17:14 4 BY Macaws flew N
																17:25 3 BY Macaws flew E
																17:30 (2+2) 4 BY Macaws flew NE from south of river
																17:36 3 BY Macaws flew NE
																17:52 3 BY Macaws flew SE
																17:56 3 BY Macaws flew N
																17:56 8 BY Macaws flew E
10/08/2010	2	Jo and Chris	Hot and Dry	19	94	0	94	0	0	Emergent	0	0	0	BY	No	

Date	Island	Names	Weather	Total No. Of Flocks	Total No. Of Individuals	No. Of Blue-Throated Macaws	No. Of Blue and Yellow Macaws	Ratio of Adults:Juveniles	Distribution	Tiered Position of BT Macaws	Tiered Position of BY Macaws	No of Trees Marked for Roosting	No. Of Trees Marked for Feeding	Dominant Species	Fruiting Trees	Other Observations
11/08/2010	5	Gwynedd and Duncan	Hot and Dry	1	2	0	2	0	0	0	0	0	0	BY	No	18:10 4 (2 pairs) of BY Macaws arrived, did not land and flew back in direction of main island
12/08/2010	6	Gwynedd and Duncan	Hot and Dry	1	1	0	1	0	0	0	0	0	0	BY	No	18:00 (approx) 2 BY Macaws circled, didnt land, and flew S
14/08/2010	3	Alwyn and Miguel	Hot and Dry	1	2	2	0	0	Random	Emergent	0	0	0	BT	No	
15/08/2010	4	Alwyn and Miguel	Hot and Dry	4	58	58	0	05:01	Clustered	Emergent	0	0	0	BT	No	
16/08/2010	1	Chris, Gwynedd, and Lydia	Hot and Dry	0	0	0	0	0	0	0	0	0	0	BY	No	17:00 3 BT Macaws flew NW-SE
																17:30 3 BY Macaws flew SW-NE
																17:30 4 BY Macaws flew W-NE
																17:41 5 BY Macaws flew E-W
																17:44 4 BY Macaws flew E-W
																17:45 1 BY Macaw flew NE-SW
																17:50 2 BY Macaws flew E-W
																17:57 2 BY Macaws flew SW-NE
																18:13 3 BY Macaws flew S-N
17/08/2010	2	Duncan and Kirsty	Hot and Dry	17	60	2	58	0	Clustered	Canopy	Canopy	0	0	BY	No	18:09 34 By Macaws circled and 6 landed

Date	Island	Names	Weather	Total No. Of Flocks	Total No. Of Individuals	No. Of Blue-Throated Macaws	No. Of Blue and Yellow Macaws	Ratio of Adults:Juveniles	Distribution	Tiered Position of BT Macaws	Tiered Position of BY Macaws	No of Trees Marked for Roosting	No. Of Trees Marked for Feeding	Dominant Species	Fruiting Trees	Other Observations
																18:20 1 BY Macaw flew SW-N
																18:25 3 BY Macaw flew SW-N
18/08/2010	5	Chris and Lydia	Hot and Dry	1	2	0	2	0	0	0	0	0	0	BY	No	18:12 The 2 BY Macaws circle, land briefly then leave, NE-SW
19/08/2010	6	Chris and Lydia	Hot and Dry	1	4	0	4	0	0	0	0	0	0	BY	No	
20/08/2010	3	Alwyn and Miguel	Hot and Dry	0	0	0	0	0	0	0	0	0	0	0	No	
21/08/2010	4	Alwyn and Miguel	Hot and Dry	1	17	17	0	All Adult	Clustered	Emergent	0	0	0	BT	No	17:05 all 17 leave, 8 flew SE, 9 + 2 from S flew to main island (SE)
																17:35 large group of cows appeared on island and no more Macaws stopped off
23/08/2010	1	Duncan and Miguel	Hot and Dry	0	0	0	0	0	0	0	0	0	0	0	No	
24/08/2010	2	Alwyn and Miguel	Hot and Dry	3	30	0	30	0	Clustered	0	Emergent	0	0	BY	No	18:06 12 BT Macaws flew S-N
																Flocks 3 to 7 leave together in 1 flock
25/08/2010	5	Kirsty and Jo	Hot and Dry	0	0	0	0	0	0	0	0	0	0	0	No	
26/08/2010	6	Kirsty and Jo	Hot and Dry	1	2	0	2	0	Clustered	0	Canopy	0	0	BY	No	Weather was humid and misty
																17:12 2 BT Macaws flew E

Date	Island	Names	Weather	Total No. Of Flocks	Total No. Of Individuals	No. Of Blue-Throated Macaws	No. Of Blue and Yellow Macaws	Ratio of Adults:Juveniles	Distribution	Tiered Position of BT Macaws	Tiered Position of BY Macaws	No of Trees Marked for Roosting	No. Of Trees Marked for Feeding	Dominant Species	Fruiting Trees	Other Observations
27/08/2010	3	Jo and Miguel	Hot and Dry	1	2	0	2	0	Clustered	0	Emergent	0	0	BY	No	Thunder
																17:08 26 BT Macaws flew N from island 4
																17:09 3 BT Macaws flew from main island to island 4
																17:33 6 BT Macaws flew N
																17:41 3 BT Macaws flew W
																17:54 9 BY Macaws flew N
																17:56 4 BY Macaws flew N
																17:58 8 BY Macaws flew N
																17:59 2 BY Macaws flew N
28/08/2010	4	Duncan and Gwynedd	Hot and Dry	2	2	1	1	0	Random	Emergent	Emergent	0	0	Both	No	
30/08/2010	1	Alwyn and Miguel	Cold and Dry	0	0	0	0	0	0	0	0	0	0	0	Yes	Thunder and Dull
31/08/2010	2	Jo and Miguel	Hot and Dry	11	48	0	48	0	Random	0	Canopy	0	0	BY	No	Very misty all afternoon, cleared up about 16:00
01/09/2010	5	Alwyn and Miguel	Hot and Dry	0	0	0	0	0	0	0	0	0	0	0	No	18:06 2 BY Macaws flew NW
																18:08 2 BY Macaws flew NW

Date	Island	Names	Weather	Total No. Of Flocks	Total No. Of Individuals	No. Of Blue-Throated Macaws	No. Of Blue and Yellow Macaws	Ratio of Adults:Juveniles	Distribution	Tiered Position of BT Macaws	Tiered Position of BY Macaws	No of Trees Marked for Roosting	No. Of Trees Marked for Feeding	Dominant Species	Fruiting Trees	Other Observations
02/09/2010	6	Alwyn and Miguel	Hot and Dry	1	10	0	10	0	Clustered	0	Emergent	0	0	BY	No	
03/09/2010	3	Alwyn and Kirsty	Hot and Dry	0	0	0	0	0	0	0	0	0	0	0	No	18:06 3 BY Macaws circle island the flew N
04/09/2010	4	Alwyn and Duncan	Hot and Dry	0	0	0	0	0	0	0	0	0	0	0	No	Dull and Very Windy