COSTA RICA FOREST RESEARCH PROGRAMME (CRF)

Osa Peninsula, Costa Rica

CRF Phase 144 Science Report
22 September 2014 – 15 December 2014

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1. Introduction

1.1 Natural History of Costa Rica and Wildlife Conservation

Despite covering an area of just 50,000 km$^2$, the Central American country of Costa Rica has high levels of biological diversity with some 12,000 species of plants, 1,239 species of butterflies, 838 species of birds, 440 species of reptiles and amphibians, and 232 species of mammals, which represent around 5% of the world’s species (Sánchez-Azofeifa et al., 2002). The extraordinary biodiversity observed here has been attributed to two main factors, the geographical location and climatic conditions of the region. Costa Rica lies about halfway between the Tropic of Cancer and the Equator with an annual average temperature of 27 °C, fluctuating little throughout the year. This small variance means that seasons in the tropics are defined by the amount of rainfall. Rainfall is much more variable than temperature, with distinct wet and dry seasons, particularly in the southern Pacific lowlands, which receive an average annual rainfall of 7,300 mm (Baker, 2012). The dry season begins around November/December and continues through to April/May, after which the rainy season commences.

Costa Rica is one of the world’s leading countries in environmental sustainability and conservation (Fagan et al., 2013), however this has not always been the case; up until the 1960s activities such as logging and hunting seriously threatened biodiversity in this region, resulting in over half of the country’s forests being cut down and many species driven to the verge of extinction (Henderson, 2002). Poaching of turtles for the fatty calipee and collection of turtle eggs has severely depleted populations of endangered black turtles (Chelonia mydas) and vulnerable olive ridley turtles (Lepidochelys olivacea) that use Costa Rica’s coastlines as nesting sites (Troëng and Rankin 2004). Similarly, the hunting of Costa Rica’s wild cat species, peccaries and tapirs for their meat, skins and other body parts has significantly reduced wild populations (Sánchez-Azofeifa et al., 2002).

Since the 1960s, some of these issues have been controlled through the implementation of several reforestation programmes, legislation, education and over 190 reserves and national parks have been created representing a total of 1,415,000 acres, 11% of the country’s land area (Sánchez-Azofeifa et al., 2001; Henderson, 2002). Costa Rican law currently protects 166 species from hunting, capture and sale, but illegal hunting still occurs, including in protected areas (Baker, 2012). Deforestation and habitat fragmentation outside of the country’s protected areas and national parks is still a large problem due to expanding human populations and rising economic pressures. The projected impacts of climate change are also likely to have significant adverse effects on this area’s biodiversity (Baker, 2012). Costa Rica, therefore, remains an important area to survey and monitor.
1.2 Osa Peninsula

The Osa Peninsula is located at the southern end of the Southern Pacific lowlands and covers an area of 1093 km² (Henderson, 2002). It is a unique ecosystem in terms of endemic species (e.g. Cherrie’s Tanager (Ramphocelus costaricensis) and Red-backed squirrel monkey (Saimiri oerstedii)) as well as possessing rich biodiversity, with over 2.5% of Earth’s living species making this peninsula an ideal location for scientific research.

The Osa Peninsula consists of Tropical Wet, Premontane Wet and Tropical Moist forest types, with elevations ranging between 200 and 760 m (Sánchez-Azofeifa et al., 2002). Due to its diverse topography, the peninsula has a variable climate, with an average annual rainfall of 5500 mm, a mean temperature of around 27°C and humidity levels almost never falling below 90% (Cleveland et al, 2010).

The Osa Peninsula has a population of around 12,000 people, mainly located in small scattered settlements. The major sources of income in the region are agriculture (rice, bananas, beans and corn), livestock (cattle), gold mining, logging and more recently the expanding eco-tourism industry (Carrillo et al., 2000). The peninsula’s population is increasing at a rate of 2.6% annually (Sánchez-Azofeifa et al., 2001). Since the 1990s, there has also been a dramatic rise in the number of hospitality businesses opening along the road from Puerto Jimenez to Carate, a result of the growing popularity of ecotourism (Minca and Linda, 2002). This has caused growing concern for the sustainability of the region’s environmental resource demands (Sánchez-Azofeifa et al., 2001).

Frontier’s Costa Rica Forest Research (CRF) programme began in July 2009 in collaboration with the local non-governmental organisation Osa Conservation, at the Piro site (N 08°23.826, W 083°20.564) in the southeast of the Osa Peninsula. The site is located within a 1700 ha private forest reserve, which is managed by the administrative unit of ACOSA (Osa Conservation Area) within the National System of Conservation Areas (SINAC). The site is a prime location for carrying out both forest and shoreline surveys, as there is relatively easy access to both the primary and secondary forest as well as the pristine beach habitat. The long term objective of the project is to investigate the effects of climate change, deforestation and anthropogenic impacts on the terrestrial communities of Costa Rica, and its impact on the country’s network of protected areas. There are six core study areas within CRF; primates, birds, butterflies, Neotropical otters, sea turtles and wild cats.

1.3 Aims and Objectives of Frontier CRF

Under the umbrella of the research programme, the specific aims and objectives of Frontier CRF are:

i) To calculate the density and abundance of the four primate species within the Osa Conservation site at Piro and its boundaries.

ii) To compare primate behaviour in different Piro Trails.

iii) To assess Neotropical river otter habitat preferences of reutilised latrine sites and investigate the role of scat deposition in intra-specific communication.
iv) To systematically test the reliability of using camera trap images to estimate the abundance of Neotropical otters by individual identification and capture-recapture analysis.

v) To assess the impacts of habitat disturbance and elevation on the distribution and abundance of six bird species of the Osa Peninsula.

vi) To monitor the activity and health of nesting marine turtles on Piro and Pejepero beaches and to support the management of the hatchery under the Osa Conservation Sea Turtle Conservation Programme.

vii) To identify Mammal Tracks within the Osa Conservation site at Piro.
2. Training

Volunteer Research Assistants (RAs) and newly appointed staff receive a number of briefing sessions on arrival (Table 1), followed by regular science lectures (Table 2) and field training (Table 3) throughout their deployments. The CRF research programme also supports candidates completing the BTEC Advanced Certificate and Advanced Diploma in Tropical Habitat Conservation and the Certificate of Personal Effectiveness (CoPE) (Table 4).

2.1 Briefing Sessions

All new arrivals to CRF are introduced to the aims of the research programme, the methodologies followed and the conservation significance of the individual studies. They are also provided with an update on the achievements of CRF. This information is delivered via the Introduction to the Frontier Costa Rica Forest Research Programme presentation. Additionally all volunteers and staff are given a full health, safety and medical briefing and are tested on this before participating in field activities. Volunteers undertaking a BTEC and/or CoPE qualification are given an introductory briefing before they begin the assessments.

<table>
<thead>
<tr>
<th>Briefing Session</th>
<th>Presenter</th>
</tr>
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<tbody>
<tr>
<td>Introduction to the Frontier Costa Rica Forest Research Programme</td>
<td>BL</td>
</tr>
<tr>
<td>Health and Safety Briefing and Test</td>
<td>DB</td>
</tr>
<tr>
<td>Medical Briefing and Test</td>
<td>DB</td>
</tr>
<tr>
<td>Introduction to the BTEC and CoPE Qualifications</td>
<td>BL</td>
</tr>
<tr>
<td>Introduction to Surveying and Monitoring</td>
<td>BL, DB, MS</td>
</tr>
<tr>
<td>Camp Life and Duties</td>
<td>BL, DB, MS, AC, AF</td>
</tr>
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</table>

2.2 Science Lectures

A broad programme of science lectures is offered at CRF providing information and training in various aspects of research. Lectures are typically presented utilising PowerPoint and give an opportunity for greater understanding of the ecology and identification of focal species, methods of data analysis used by CRF and considerations when planning research projects.

Lectures are scheduled with the following objectives:

- Allow every volunteer and member of staff to attend each presentation at least once during deployment, regardless of length of stay.
- Meet the time requirements for BTEC assessments.
- Avoid conflict with other activities, maximizing attendance.
- Workshops provide detailed training on specific software and applications used in conservation.

Attendance of lectures is non-compulsory.
Table 2. Science lectures delivered during Phase CRF144

<table>
<thead>
<tr>
<th>Science Lecture</th>
<th>Presenter</th>
<th>Date(s) Delivered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survey Planning: BTEC E07 Preparation</td>
<td>BL</td>
<td>27 October 2014; 03 November 2014; 25 November 2014</td>
</tr>
<tr>
<td>Surveying and Monitoring: BTEC E09 Preparation</td>
<td>BL</td>
<td>04 November 2014; 10 November 2014</td>
</tr>
<tr>
<td>Mammal Track Workshop</td>
<td>JB, LB</td>
<td>11 October 2014; 17 November 2014</td>
</tr>
</tbody>
</table>

2.3 Field Training

All volunteers and newly appointed staff receive field training. Training is hands-on and provides an opportunity for participants to become familiar with and use the field equipment. The following topics are covered:

- Specific training sessions to prepare volunteers and staff for accurate data collection
- Identification of flora and fauna
- Survey method training
- Skills and tools used for research
  - Turtle tagging
  - Proper maintenance of equipment

Table 3. Field training provided during Phase CRF144

<table>
<thead>
<tr>
<th>Field Training</th>
<th>Provider</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turtle Tagging</td>
<td>BL, DB, MS</td>
</tr>
<tr>
<td>Turtle Patrol Data Collection</td>
<td>BL, MS, DB, KH</td>
</tr>
<tr>
<td>Primate Surveys by Distance-sampling</td>
<td>KH, DB, MS</td>
</tr>
<tr>
<td>Bird Surveys by Point Surveys</td>
<td>DB</td>
</tr>
<tr>
<td>Butterfly handling and Identification</td>
<td>BL, MS</td>
</tr>
<tr>
<td>Field Equipment: GPS, Laser Rangefinder and Clinometer</td>
<td>BL, DB, MS</td>
</tr>
<tr>
<td>Identification of Neotropical Otters and their Signs, and</td>
<td>BL, MS, DB</td>
</tr>
<tr>
<td>Recording River Attributes</td>
<td></td>
</tr>
<tr>
<td>Studying Primate Behaviour</td>
<td>DB, KH, MS</td>
</tr>
<tr>
<td>Staff Turtle Training</td>
<td>Osa Conservation</td>
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</tbody>
</table>
2.4 **BTECs**

Frontier offers volunteer Research Assistants an opportunity to gain internationally recognised qualifications based around teamwork, survey techniques, environmental conservation and effective communication of results. The BTEC in Tropical Habitat Conservation may be studied as an Advanced Certificate (four week program) or Advanced Diploma (ten week program). See Table 4 for the BTECs undertaken during this phase.

<table>
<thead>
<tr>
<th>Name</th>
<th>BTEC Title and Type</th>
<th>Mentor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Philip Cliff</td>
<td>A comparison of turtle nest predation levels in Pejeperro and Piro Beach (Advanced Diploma)</td>
<td>BL, DB</td>
</tr>
<tr>
<td>Francesca Standeven</td>
<td>Abundance of Roadside Hawks in two different environments, road edges and open areas. (Advanced Diploma)</td>
<td>BL, DB</td>
</tr>
<tr>
<td>Jason Russell</td>
<td>Comparing two different methodologies, point counts and transects, to measure butterfly abundance and distribution (Advanced Diploma)</td>
<td>BL, DB</td>
</tr>
</tbody>
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3. **Research Work Programme**

3.1 **Survey Areas**

Field research is conducted within an 11.83 km² privately-owned property in Piro, Osa Peninsula and its boundaries (8°23'-8°26'N, 83°18'-83°25'W) (Figure 1). Located largely within the Golfo Dulce Forest Reserve and Osa Conservation Area (ACOSA) Wildlife Refuge, this property is owned by NGO Osa Conservation (OC). The landscape is heterogeneous, composed of lowland moist primary, secondary and coastal forest. Dominant tree species include; *Ficus insipida*, *Ceiba pentandra*, *Attalea butyracea*, *Carapa guianensis*, *Castilla tunu*, *Spondias mombin*, *Hyeronima alchorneoides*, *Chimarrhis latifolia*, *Fruta dorada*, *Caryocar costaricense*, *Ocotea insularis*, *Pouteria torta*, and *Inga allenii*. This property also borders dense forest and pastoral properties to the southeast, and encompasses pochote (*Pachira quinata*) and teak (*Tectona grandis*) plantations in the north and northeast, each occupying 0.4 km². There are two biological research stations within the survey area; Cerro Osa station in the northwest and Piro station in the southern region of the property. Mean annual rainfall and temperature for the area is 5,000-6,000 mm and 26-28 °C respectively; the dry season extends from the end of December until March.
Figure 1. The Frontier Costa Rica Forest Research Programme study area with research beaches, rivers and trails marked. LS: Laguna Silvestre; NT: New Trail; TP: Terciopelo; PT: Piro; BT: Beach Trail; LH: Los Higuerones; AT: Ajo; CA: Chiricano Alegre; CO: Cerro Osa; NB: Northern Border; CT: Chicle.

A forest trail network covers most of the southern and north eastern portions of the site. The majority of the trails are narrow and machete-cut. Exceptions to this are Cerro Osa, which is an old logging road, and the north-south segment of Northern Border and Laguna Silvestre which are both 5 m wide cleared tracks. New Trail is the most recently cut trail and is approximately one year old, while all other trails are more than five years old.

The property is bordered to the south by the Pacific Ocean and the coastline is separated into two beaches – Playa Piro (2 km) and Playa Pejeporro (4.5 km). The primary rivers intersecting the property are the Rio Piro and the adjoining Quebrada Coyunda; the mouth of the former is at approximately the centre of Playa Piro.

3.2 Local Population Density of the Four Primate Species Coexisting in Costa Rica

3.2.1 Introduction

There are four species of primate found in Costa Rica; the Central American squirrel monkey (Saimiri oerstedii), Mantled howler monkey (Alouatta palliata), Geoffroy’s spider monkey (Ateles geoffroyi) and White-faced capuchin (Cebus capuchinus). All four species are present at the study site in Piro. A. geoffroyi is listed as Endangered, S. oerstedii as Vulnerable, whereas A.
*palliata* and *C. capuchinus* are listed as least concern (IUCN, 2013). Population declines exceeding 50% over 45 years have been reported for *A. geoffroyi*, principally driven by stress-induced habitat loss (Cuarón *et al.*, 2008b). *S. oerstedii* has a limited distribution, restricted to Panama and Costa Rica, meaning that populations exploited for the pet trade and those experiencing habitat loss and degradation are already vulnerable to stochastic events. Land conversion for agriculture and development, clear cutting, selective logging and the pet trade have implications for all four Costa Rican primate species (Cropp and Boinski, 2000).

The primate guild in Costa Rica is vital to forest structural integrity. All four species perform important roles as seed dispersers (Julliot, 1997; Garber *et al.*, 2006) and the Osa Peninsula is the only part of Costa Rica where all four species occur together (Carrillo *et al.*, 2000).

Frontier CRF has been surveying the presence and abundance of all four species in collaboration with Osa Conservation since March 2010. The overall aim of this research is to provide an insight into the habitat use and behaviour of primates in the area to better aid management and policy decisions at a local level. The principal and foremost objective of this project is to produce estimates of population density for each of the four species.

### 3.2.2 Methodology

Data is collected following a standardised line-transect sampling protocol (Buckland *et al.*, 2010; Thomas *et al.*, 2010). The trails are sampled equally across times of day. Surveys are taken at 0600, 0800, and 1400 hours to cover peak primate activity, increasing the detection probability. Transects include, for the most part, combinations of forest trails. Transects sampled (Table 5) are walked by two observers at a constant speed of 1.5 – 2 km per hour as recommended by Karanth and Nichols (2002). No transect is surveyed more than once on the same day and sampling is only conducted in fair weather due to the reduction in detection probability in adverse weather conditions.

The research was non-invasive and adhered to the legal requirements of Costa Rica. Any and all aggressive behaviour towards the observers by individual primates was responded to by moving on as quickly as possible.

<table>
<thead>
<tr>
<th>Transect Name (code)</th>
<th>Transect Length (km)</th>
<th>Habitat Description and Trail Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ajo (AT)</td>
<td>3.1</td>
<td>Trail through secondary and mature, primary forest</td>
</tr>
<tr>
<td>Terciopelo – Piro (TP – PT)</td>
<td>2.3</td>
<td>Trail through riparian, primary and secondary forest</td>
</tr>
<tr>
<td>Cerro Osa (CO)</td>
<td>1.9</td>
<td>Old logging road and forest trail through secondary and mature, primary forest, abandoned pochote (<em>Pachira quinata</em>) plantation and across a branch of the</td>
</tr>
</tbody>
</table>
All primates observed were recorded and the spatial location noted using GPS. The number of individuals within the target group and the perpendicular distance from the transect line to the geometric centre of the group at first sighting was also recorded. All individuals visible at the same time and exhibiting the same general behaviour (e.g., resting, moving or foraging) were considered to be part of the same group (Chapman et al., 1995). Agreement upon group size was made between the observers where the group could be counted together; otherwise the observers split their search effort into non-overlapping areas (e.g., left and right of the trail) and made independent counts which were then summed. Where possible, secondary data on group composition (i.e. gender and age group; adult, juvenile, infant) was also recorded, however vocal detections were not included.

The perpendicular distance to the centre of the group was calculated using the radial distance $r$ and the sighting angle $\theta$, which are related to the perpendicular distance $x$ by the formula $x = rsin\theta$. The sighting angle was measured with a compass and the radial distance calculated using the formula $r = dcos\theta$, ($r$=radial distance, $d$ = direct distance measured with a laser rangefinder between the observer and the geometric centre of the group, $\theta$=the slope angle between the observer and the geometric centre of the group measured with a clinometer. Alternatively, where field conditions permitted, a tape measure was used to measure the perpendicular distance. After every recorded observation, the observers immediately continued along the transect noting any direction of animal movement to eliminate the chance of recording the same individuals more than once per survey.

Data were analysed using DISTANCE ver. 6.0 (Thomas et al., 2010) under the following assumptions; i) all groups at zero perpendicular distance to the line were detected with certainty; ii) groups were detected at their initial locations and were not counted twice, and; iii) accurate measurements of distances were made from the line to the geometric centre of the group (Thomas et al., 2010). As trails were concentrated around the southern edge of the property, our survey effort was not evenly distributed within the study area. The study site was therefore divided into two substrata to avoid bias: an area of 1.67 km$^2$ in the southern region of the
property (encompassing trails Terciopelo-Piro, Beach Trail-Road, Ajo, Chiricanos Alegre-Cerro Osa-Los Higueros and the lower 414 metres of Cerro Osa) and an area of 10.16 km² in the northern and western sections of the property (encompassing trails Chicle, Northern Border, Laguna Silvestre, New Trail-Road and the remaining 1052 m of Cerro Osa). These two sections were considered as two substrata layers in DISTANCE (Buckland et al., 2010).

The conventional distance sampling (CDS) function was employed to permit stratification of the two sections of the property. The data was truncated by 10% (Buckland et al., 2001). Cluster size regression analysis was selected for each model. In these cases, the mean of observed cluster sizes was chosen to estimate the statistical cluster size (Link et al., 2010). As there were several replicates for each trail, the number of samples was added as a multiplier to the CDS model in order to account for the survey effort (Leca et al., 2013).

Several candidate models were tested and the most parsimonious model was selected based on Akaike Information Criterion values AIC. The suitability of each model was also determined using chi-square ($\chi^2$) goodness of fit (GOF) tests (cf. Leca et al., 2013); significant results of $\chi^2$ analysis suggest that the model does not fit the data (Buckland et al., 1993).

The data was stratified at the sample level and density estimates were pooled using the mean density estimates of the two substrata, weighted by strata area to compensate for the large difference in the areas surveyed. Detection function and cluster sizes were estimated at the global level.

### 3.2.3 Results

Data from phase 144 was added to data from previous phases and analysed. In total 368 surveys carried out from September 2013 and December 2014. The most frequent species encountered was the spider monkey, with the squirrel monkey being the least frequent (Figure 2).
Figure 2: Number of encounters of each primate species found on all the trails. (SQ=squirrel monkeys, SP=spider monkeys, HO=howler monkeys, CA=capuchins). Trails names and habitat descriptions are summarised in Table 5, see above.

Spider monkey population density:

There were 162 spider monkey encounters with 115 being used for analysis over 20 replicates of each trail at each time. For analysis, the most suitable model was the uniform key with cosine polynomial expansion. The density that was estimated was 34.36 individuals/km² with a mean cluster size of 3.98. The northern region had more individuals per kilometre than the southern region, with 36.42 in the northern and 30.3 individuals in the southern. Although the northern region had more individuals per kilometre, Northern Border had the lowest number of encounters with only 11 compared to New Trail Road having 68 encounters.

Howler monkey population density:

From September 2013 through to December 2014 a total of 66 howler monkey encounters were recorded. After truncation, 59 encounters were used for analysis and the most suitable model was the half normal key with cosine polynomial expansion. This estimated the density of the howler monkey to be 30.8 individuals/km². Mean cluster size was 8.3. The southern region had a higher density of howler monkeys in comparison to the northern region. New Trail Road and Beach Trail Road had the highest number of encounters of howler monkeys with 17 on each and Northern Border had the lowest number with only 4 encounters over the survey period.

Species estimates are not provided here for capuchin and squirrel monkeys as sampling at the time of writing is uneven across transects and times. Only when trails have been equally and adequately sampled will a density estimate be reported. However, from the surveys carried out, New Trail Road has seen the highest number of encounters for both species, 26 and 13 respectively. For squirrel monkeys there have been no sightings on the Northern Border trail and only 1 encounter of capuchins on Beach Trail Road.

3.2.4 Discussion

Previous research has shown that 60-80 observations per species should be used to calculate population density. At this present moment we have an insufficient number of encounters to calculate the density of white-faced capuchins and Central American squirrel monkeys. As all four primate species have a vital role in seed dispersal it is important to gain baseline data for all four species in the near future (Mittermeier, 1987).

The number of spider monkeys estimated in this area is lower than expected when compared to the population density found in Corcovado National Park (CNP), which stands at 68.45 individuals per km², double the estimates found within this study area. Within the Piro study area, there are a large number of tree species that represent an important food source for the spider monkeys and human disturbance is kept at a minimum, with the closest village or road situated 19km away from the park. These have previously been identified as contributing factors to the high species density in CNP, therefore, there must be another factor causing the lower
densities found within the Piro study area (Weghorst, 2007). Spider monkeys are sensitive to disturbance, this may be related to the high levels of human activity and research in our study area (Cuarón et al., 2008a). CNP is a protected area, however, many areas outside CNP are experiencing habitat fragmentation, which could result in a decline in species dispersal throughout the region. Although Piro study area is small, it is highly important, as it is part of the Golfo Dulce Forest Reserve and forms a biological corridor between the the Piedras Blancas National Park and CNP (Stem et al., 2008). If reforestation efforts are increased in the area then the effects of fragmentation may be reduced. Future studies can utilise the density estimates from this study as a baseline for comparison, facilitating long-term monitoring of the local populations.

Chapman and Balcomb (1998) used data from a census of Guanacaste National Park, Costa Rica, to estimate the population density of mantled howler monkeys. This study suggested an average of 49 individuals per km\(^2\). Previous research in Costa Rica has shown populations can be as low as 7.9 individuals/km\(^2\) (Fedigan et al., 1998). Although our population density (30.8 individuals/km\(^2\)) is higher than this estimate, it is below other areas in Costa Rica. The average group size found in our study, 8.3 members, also falls below average in comparison to other populations, which show an average of 10.7 members (Chapman and Balcomb, 1998). One reason for this could be the difficulty in recording every individual within a group as they generally live in the upper canopies (Glander, 1980). Previous research suggests howler monkeys may form subgroups where resources are limited which could also be a contributing factor to a lower population estimate (Chapman, 1990). Similar to the spider monkeys, habitat loss and fragmentation may result in a decline in the number of howler monkeys found. Large fruiting trees such as the American oil palm (Elaeis oleifera) or the strangler fig (Ficus aurea), are essential for howler monkeys and fragmentation may result in the mortality of these trees (Dunn et al., 2009). Additional research is needed within the area to determine the pressures faced from the primate species in relation to fragmentation.

Population estimates from the studies described here can be used to contribute to future studies within the region. By using this data with other techniques, such as soundscaping, there will be a better understanding of the level of disturbance within the region and will provide information to focus future studies. Overall, this will indicate the impact of anthropogenic activities and aid in management and policy decisions.

### 3.3 Comparing behaviour of the Four Primate Species in different Piro Trails

#### 3.3.1 Introduction

Costa Rican primates have evolved to fill specific niches through variable body size, activity levels, and dietary preference. Mantled howler monkeys form stable groups ranging from 2-39 individuals and their diet is based on leaves situated in the top canopy (Di Fiore & Campbell, 2007). The Central American squirrel monkey prefers river edge forest and secondary forests and feeds on fruits and insects from the lower canopy and understorey, travelling in groups of up to 75 individuals (Graham et al., 2013). Geoffroy’s spider monkeys are highly frugivorous
foraging in the upper levels of the primary lowland rainforest and travel in small groups 2-6 individuals, whereas White-faced capuchin live in troops of up to 40 individuals and feed predominantly on fruits and insects at all levels of secondary and primary forest, including the ground level (Di Fiore & Campbell, 2007).

The trails within the Piro Property comprise a wide range of environments including lowland moist primary, secondary and coastal forest (Table 5). In this study, we compare the behaviour of the four primate species in different trails around this area to understand the interactive relationship between primate behaviour and the environment and to manage these areas of the forest accordingly

3.3.2 Methodology

Data was collected at different times of the day 0600, 0800, and 1400 hours to cover peak primate activity, following a standardised line-transect sampling protocol (Buckland et al., 2010; Thomas et al., 2010). All trails are surveyed an equal number of times and at each of the time slots over the survey period.

The primate species and the group size and composition were recorded and the spatial location noted using GP. The behaviour of all individuals visible at the time was recorded using instantaneous sampling which record the activities of each individual every minute over a 10 minute period.

The standard behaviour categories recorded during field work were:

- Locomotion – Moving from one point to another;
- Resting - Lying down, sitting, not exhibiting any other type of behaviour;
- Foraging/feeding – Searching for or eating different foods;
- Social interaction – Grooming, sexual behaviour or close contact within species;
- Aggression – Threatening, chasing, hitting or bighting within species;
- Behaviour towards humans – Scratching fur, throwing sticks etc and shaking branches, all directed towards observer; and
- Other – Any behaviour not falling into the above categories.

3.3.3 Results

Figure 3 summarises the percentages of the fourth most observed behaviours for each primate species around the Piro Property. All four species displayed Feeding, Locomotion, and Social Interaction among the most observed behaviours. Resting was displayed by all primates except for spider monkeys which were observed exhibiting behaviour towards humans in 46% of the observed time. Feeding was the most common displayed behaviour for white-faced capuchins, locomotion was the most common for squirrel monkey, whereas resting was the most common behaviour for howler monkeys. The least displayed behaviour was social interaction for all primate species.
Figure 3: Percentage of behaviours observed for each primate species in all trails around Piro Property.

At the moment of writing data was uneven across transects and times, therefore, the behaviour of primates was only analysed for three of the existing trails. The behaviour towards humans was created by the presence of the surveyor, thus, it was excluded from this analysis.

Most primates observed at the three trails were displaying locomotion and feeding as the most common behaviour. Feeding was predominant in the Beach Trail, whereas locomotion was the most observed behaviour in New Trail. In contrast, Ajo Trail had an equal number of primates exhibiting locomotion and feeding behaviours. Additionally, there were a higher number of primates observed feeding or foraging at Beach Trail than in any other trail.
3.3.4 Discussion

Researchers have long been concerned that their presence may change the behaviour of their study subjects, affecting foraging decisions or disrupting resting periods (Nowak et al., 2014). Some studies have found that human presence can have a negative effect on movement, foraging, and reproductive behaviour of some species, especially during sensitive times such as breeding (Klein et al. 1995; Nowak et al., 2014); however, long-term studies of primates often report increases in population size, probably due to decreased predation associated with the presence of human researchers (Griffiths & Van Schaik 1999; Graham et al., 2013). Most species were observed around Piro property without disturbing normal activity. This suggested that species around this area were habituated to human presence, likely due to the long term presence of researchers at Frontier and Piro Biological Station and regular eco-tourism to the area. Spider monkeys, however, exhibited a high percentage of aggressive behaviour towards humans when observations were carried out. Behaviours such as shaking tree branches, making noises or throwing branches or fruits, are considered normal behaviours among spider monkeys in the wild (Graham et al., 2013). Spider monkeys used these techniques to scare away a possible threat, that being the surveyor. It is expected that negative responses to humans will decrease over time as more research is carried out in the area and primates habituate to human

Figure 4: Most common behaviours displayed by all primate species in three trails (Beach, New and Ajo Trails) around Piro Property. Red colour indicated the most observed behaviour for each trail.
researchers (Crofoot et al. 2010). In contrast, Howler monkeys were less active and did not travel as much as the other three species; howler monkeys receive less protein from the leaves they eat and digestion is complex and slow, therefore, they exert less energy and have extended periods of rest (Di Fiore & Campbell, 2007). Additionally, our observations of Squirrel monkeys and white-faced capuchins showed that these were the most active primates, eating, foraging and travelling to find fruits and insects with high energy content, allowing higher activity levels for these two primate species (Graham et al., 2013).

Beach Trail comprises secondary forest with many fruit trees such as the American oil palm (*Elaeis oleifera*), which was in season at the time of data collection. This could be related to the increased number of primates feeding and foraging in this area at the time of the study. New Trail also includes secondary forest, however, this trail has two different areas, river and swamp, which provide a wide variety of flora for primates to forage, therefore, primates may spend more time travelling from one area to the other within the trail in order to get food and in search of resting areas not available in this trail. On the other hand, within Ajo Trail, primates were found to exhibit locomotion and resting behaviour in equal amounts and an increased amount of time resting comparing to the other trails. This correlates with the availability of resources provided by the forest composition of this trail, comprising secondary and mature primary forests, which provide important resources for foraging and resting sites.

Although the present study is in its early stages, with methodology under revision and increased data collection needed before statistically analysis can be performed, behaviours between and within species of primate are already highlighting the importance of protecting areas that contain preferred food plants, especially in connecting habitats like Piro that buffer Corcovado National Park. Additionally, it has been shown that anthropogenic disturbances could potentially have detrimental effects on the viability of spider monkey populations, through alteration of their behaviours.

### 3.4 Neotropical River Otter Habitat Preferences of Reutilised Latrine Sites and the Role of Scat Deposition in Intra-Specific Communication

#### 3.4.1 Introduction

The Neotropical River Otter (*Lontra longicaudis*) is a solitary species that can be found in a variety of habitats including swamps, streams and lagoons from Mexico to Uruguay (Emmons and Feer, 1997; Quadros et al., 2002; Gori et al., 2003; Santos et al., 2012). Although otters are an adaptive species and have been reported to inhabit irrigation ditches in rice and sugar cane plantations in Guyana (IOSF, 2012), their low reproductive potential and dependence on healthy aquatic environments, means that the species cannot respond quickly to population crashes (Cezare et al., 2002; Waldemarin and Alvarez, 2008). Despite this wide distribution, little is known about the species’ ecology, local distribution and population status, hindering the development of appropriate conservation strategies. The Neotropical river otter is currently listed as “Data Deficient” on the IUCN Red List of Threatened Species (Waldemarin and Alvarez, 2008). This is because relatively little research effort has been devoted to the study of the species throughout its range, and detailed habitat and ecology information is lacking.
Otters are secretive and difficult to observe, thus necessitating alternative methods to monitor their status and distribution. In contrast, otter latrines or haul-outs, places along the shoreline where otters eat, defecate, urinate, roll and deposit anal sac secretions, are often obvious evidence of otter activity (Bowyer et al., 1995; Crowley et al., 2012). Latrines are located several meters from the water on high ground (e.g. logs, rocks) (Quadros and Montiero-Filho, 2002; Stevens and Serfass, 2008; Depue and Ben-David, 2010) and mark territorial boundaries within otter home ranges (Melquist and Hornocker, 1983; Remonti et al., 2011). The exact purpose of latrines is not conclusively known, but they are believed to play a role in intra-specific communication (Melquist and Hornocker, 1983; Rostain et al., 2004; Kasper et al., 2008), signalling reproductive state to the opposite sex (Rostain et al., 2004), marking areas of key resource use (Kruuk et al., 1986; Kruuk, 1992) and conveying the social status of males (Rostain et al., 2004).

Numerous environmental characteristics such as water depth (Anoop and Hussain, 2004; Depue and Ben-David, 2010; Remonti et al., 2011; Carrillo-Rubio and Lafón, 2004), water edge topography (Swimley et al., 1998; Bowyer et al., 1995; Anoop and Hussain, 2004) and vegetation structure (Prenda and Granada-Lorencio, 1996) are reported to influence latrine site selection, however discrepancies exist regarding the importance of each factor. In addition, numerous other interacting factors are likely to promote latrine site selection. Therefore, habitat preference studies are essential to better comprehend the distribution, abundance, and requirements of the Neotropical Otter.

In this study, the aim is to investigate the Neotropical river otter habitat preferences in terms of reutilised latrine sites and investigate the role of scat deposition in intra-specific communication.

3.4.2. Methodology

Two linear transects were established along the course of the Rio Piro and Quebrada Coyunda measuring 5.2 km and 2.8 km respectively (Fig.5). Each river was surveyed once a week, typically as two distinct transects. One began at CRF camp and ran 3.5 km north on the Rio Piro. The other began at CRF camp and started 1.7 km south on the Rio Piro to the river mouth and then ran 2.8 km east of the Quebrada Coyunda from the intersection with Rio Piro. Surveyors walked within the river course and typically began sampling early morning to avoid afternoon rain, characteristic of the rain forest.
Figure 5: Map of otter transects along Rio Piro and Quebrada Coyunda.

During the course of the survey; all reutilised sites such as rocks, logs, fallen trees, roots and river margins were actively searched for otter spraints. We defined reutilised latrines as sites having two or more scats present (Stevens and Serfass, 2008). The substrate diameter where the spraint was deposited, stream depth adjacent to the substrate and distance to the waterline was recorded. At each site, GPS data was collected and river width and river depth at 1 m intervals of the river cross-section was measured. The presence/absence of mucous in spraint was also recorded and escape cover distance, defined as the distance from the water’s edge to the point where the undergrowth started, was collected for both river margins.

3.4.3 Results

Data collection has been progressing slowly due to Health and Safety issues with rising river levels; more intensive sampling will take place during the dry season. No analyses have been undertaken for this Phase.

3.4.4 Discussion

This project is still in its early stages and more data is needed to investigate possible patterns developing within this area and to expand the project’s knowledge regarding the effect of environmental characteristics on reutilised latrines.

3.5 Using Camera Traps to Estimate Species Abundance of Otters

3.5.1 Introduction

Basic information on population abundance is vital in conservation research to assess species current status, monitor temporal trends and define conservation priorities (Mackenzie, 2005; Oliveira-Santos et al., 2010). Without robust data on distribution and abundance, conservation
strategies and management practices may be misguided, ineffective and inefficient (Langbein et al., 1999; O’Brien, 2008; Hájková et al., 2009; Obbard et al., 2010).

The Neotropical river otter (Lontra longicaudis) is a Data Deficient species with no data existing for population size (Waldemarin and Alvarez, 2008). At present, no standardised method for estimating the abundance of the species exists, however, it is thought that the species is rare and declining throughout its range from north western Mexico to Peru and Uruguay (Santos et al., 2012). Therefore, field surveys of populations are one of the IUCN’s conservation priorities for the species (Waldemarin and Alvarez, 2008). Furthermore, developing standardised identification methods is essential for reliably comparing data on multiple spatial and temporal scales.

The difficulties associated with assessing the abundance of otters (Family: Mustelidae) by direct observation are due to low encounter frequencies. Alternative approaches are required (Hájková et al., 2009), such as recording distinct otter spraints (Davison et al., 2002), however, estimating abundance and therefore assessing population status of elusive and rare species is often difficult (Balme et al., 2009; Hájková et al., 2009). Using sprainting intensity as an index of otter abundance is unreliable as it may reflect the abundance of suitable, conspicuous sprainting sites and activity rather than true population size (Guter et al., 2008; Calzada et al., 2010).

Camera trapping is a relatively new methodological advancement (Pettorelli et al., 2009) that uses specialised equipment to detect and capture photographs of passing animals (Rowcliffe et al., 2008). Since its early applications in the 1920s, camera traps have become an increasingly popular tool in non-invasive wildlife research (Rowcliffe and Carbone, 2008). The most common application of camera trapping is for the abundance estimation of wild cat species (Rowcliffe and Carbone, 2008), which is most often calculated by simultaneously photographing the left and right flank of animals with paired camera traps. This results in capture histories of individuals identified by their unique striping or spot patterns and an estimation of population parameters by capture-recapture analysis (Karanth, 1995). Camera trap studies of non-striped and non-spotted species are less represented and are generally limited to species inventories, rather than estimating abundance or density (Rowcliffe et al., 2008). Applying the camera trapping methodology to these species will substantially increase the value of this tool, no longer limiting its use to only those species with unique identifying markers (Rowcliffe and Carbone, 2008).

Trolle et al (2008) argue that species that lack conspicuous stripes and spots may be identified to individual level by subtle marks, coat colouration, scars, body structure and gender. This approach has been applied in a number of studies concerning various taxa (e.g. coyotes (Canis latrans) (Larrucea et al., 2007); foxes (Vulpes vulpes) (Sarmento et al., 2009); maned wolves (Chrysocyon brachyurus) (Trolle et al., 2007); tapirs (Tapirus spp.) (Holden et al., 2003; Noss et al., 2003; Trolle et al., 2008); and pumas (Puma concolor) (Kelly et al., 2008). It is possible that individuals may be misidentified if shallow scratches fade (Trolle et al., 2008), if photographs are captured in different light and humidity conditions, as well as discrepancies through varying approach path angles and distances relative to the camera (Oliveira-Santos et al., 2010). The reliability of individual identification of non-spotted and non-striped species has
been investigated using tapirs as a case study, reporting very poor levels of accuracy (Oliveira-Santos et al., 2010).

It is believed that otters may be individually identified using markings on their chins (Chanin, 2003), however, the reliability of this method has not been systematically investigated. It has been suggested that future studies validate these theories using data from captive individuals to test whether inter-individual variation at the population level is sufficient to reliably distinguish between individuals (Foster and Harmsen, 2012). Furthermore, for camera trap data to be analysed by capture-recapture methods, unique identifying markers must be visible in every photograph (Foster and Harmsen, 2012). Alternatively, where individuals of a species cannot be identified, novel methods reveal potential pathways for estimating abundance from measurements of animal and camera parameters using the images themselves without the need to identify individuals (Rowcliffe et al., 2008).

The specific objectives of this study are to: i) investigate the ability of researchers to identify individual Neotropical river otters (Lontra longicaudis) in a set of photographs of a population with a known size; ii) investigate which characteristics are used by the researchers to identify individuals within the population; iii) quantify the proportion of camera trap photographs which are discarded on the basis of inability to identify individuals; iv) assess the effect of any inter-researcher variability in individual identification on the reliability of species abundance estimates by capture-recapture analysis, and; v) provide informed recommendations towards developing standardised methodologies for estimating the abundance of Neotropical river otters in the wild.

3.5.2 Methodology

Camera trapping are being conducted within the captive area(s) of animal collections holding at least one individual Neotropical river otter. Cameras will be active 24 hours a day. The resulting images will be grouped into three subsets: (1) right flank of animal captured; (2) left flank of animal captured; (3) animal facing camera. Cameras will be active until greater than 50 images within a single subset have been captured and it is agreed with animal collection staff that all individuals have been photographed at least once. Animal collection staff will also be asked to identify the individual(s) in each photograph.

The photographs will be sent to members of the IUCN Otter Specialist Group and other otter researchers who will be invited to respond to the following questions: (1) How many individuals were identified?; (2) What parts or characteristics of the animals were considered relevant in the identification of individuals?, and (3) How many photos were discarded as inappropriate for identification? Respondents will also be asked to identify the individual(s) in each photograph, giving a unique numerical identifier to each individual.

The number of individuals identified by each participant will be expressed as a simple calculation of error, proportion of over-estimation or under-estimation in relation to the known
population size. Characteristics used by respondents to identify individuals will be assessed to investigate any trends in accuracy of estimate and characteristic(s) used. The proportion of photographs discarded will be expressed as a percentage of the total number of photographs collected. Capture-recapture methods will be applied to the capture histories created from participants’ responses containing unique numerical identifiers for individuals in each photograph and abundance estimates calculated in CAPTURE. These values will be compared with the estimate derived from the capture history based on responses from animal collection staff.

3.5.3 Results

Camera trap images are still being collected at the time of writing.

3.5.4 Discussion

No results to discuss this phase.

3.6 A baseline study assessing the impacts of habitat disturbance and elevation on the distribution and abundance of six focus birds species (including four endemic) of the Osa Peninsula:

3.6.1 Introduction

The highly multifaceted and heterogeneous environments of Costa Rica have many species-rich communities; particularly those within the avian families (Herzog et al., 2002). Due to their sensitivity to change, birds are well known as important indicators of the health of the ecological habitats in which they reside. The avifaunal communities of Costa Rica are infamous for their wealth in diversity, with over 800 species documented (Henderson, 2010), however declining populations are becoming more frequent with pervasive human influences. The complex and myriad of interactions between trees and the birds that destroy or disperse their seeds play crucial roles in these ecosystems (Howe, 1980) and with falling populations, falling pollination and seed dispersal rates are seen, both which are fundamentally key functions of any stable ecosystem (Pejchar et al., 2008). Together with the fact that many of these species are endemic to particular habitats within Costa Rica, it is important to regularly and closely monitor the bird communities. Trends are impossible to measure unless some baseline is first established (Bibby et al., 1998), followed by the assessment of biotic and abiotic factors on avifaunal distribution, which has been successfully undertaken by many authors (Blake & Loiselle, 2000).
In the past Costa Rica was densely forested prior to human intervention, yet large areas have now undergone major deforestation in favour of agriculture, logging or development and it is suffering from one of the world’s highest rates of deforestation of unprotected forest (Powell et al. 2000), creating dramatic alterations to the ecosystems. With this in mind, and the fact that there are wide gaps in the understanding of tropical bird communities (Herzog et al. 2002), this project aims to support the ongoing assessment of tropical bird communities of the Osa Peninsula. The project started in early October 2014, after some initial pilot studies, with the intention of assessing the species distribution of six focus species of the Osa Peninsula in order to start a baseline survey.

In order to provide a more concise study we selected six individual bird species as focus species unique to this study, with four being endemic to the area. The six focus species are listed in Table 6 with additional details of their conservation status and species range taken from IUCN Red List (2014) and Henderson (2010). Four of these, the Fiery-billed Aracari (*Pteroglossus frantzii*), Riverside Wren (*Thryothorus semibadius*), Cherries Tanager (*Ramphocelus costaricensis*) and Orange-Collared Manakin (*Manacus aurantiacus*) are endemic to the region of South West Costa Rica and western Panama. It was determined that those species of the Manakin family found in the region and endemic to Central America, including the Blue Crowned (*Lepidothrix coronate*) and Red Capped Manakin (*Pipra mentalis*), should also be assessed over the course of the study as they typically inhabit lowland forests. All species will be analysed in order to ascertain a baseline population survey before further determining impacts, if any, from past and current human disturbance and differences in population densities across elevation gradients.

<table>
<thead>
<tr>
<th>Species</th>
<th>Endemic Range</th>
<th>IUCN Status</th>
<th>Pop Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiery-billed Aracari (<em>Pteroglossus frantzii</em>)</td>
<td>SW Costa Rica to W Panama</td>
<td>Least Concern</td>
<td>Decreasing</td>
</tr>
<tr>
<td>Riverside Wren (<em>Thryothorus semibadius</em>)</td>
<td>SW Costa Rica to W Panama</td>
<td>Least Concern</td>
<td>Unknown</td>
</tr>
<tr>
<td>Cherries Tanager (<em>Ramphocelus costaricensis</em>)</td>
<td>SW Costa Rica to W Panama</td>
<td>Least Concern</td>
<td>Stable</td>
</tr>
<tr>
<td>Red-Capped Manakin (<em>Pipra mentalis</em>)</td>
<td>Belize to Panama</td>
<td>Least Concern</td>
<td>Decreasing</td>
</tr>
<tr>
<td>Blue-Crowned Manakin (<em>Lepidothrix coronate</em>)</td>
<td>Costa Rica to Brazil</td>
<td>Least Concern</td>
<td>Decreasing</td>
</tr>
<tr>
<td>Orange Collared Manakin (<em>Manacus aurantiacus</em>)</td>
<td>SW Costa Rica to W Panama</td>
<td>Least Concern</td>
<td>Decreasing</td>
</tr>
</tbody>
</table>

It is hoped that this project can be the start of many feeder projects assessing differences in the communities of the six focus species across elevation and habitat gradients, particularly human created gaps, using the definition of Levey (1988) whereby a gap is a “vertical hole in the forest extending through all levels down to within an average of 2 m above ground” (Levey
It is hoped that the project can focus on sampling the populations at dawn, and possibly dusk in the future over the coming phase. Trails examined encompass primary and secondary forest as well as swamp and river habitats, with trails ranging over low to higher elevations.

### 3.6.2 Methodology

In a similar manner to Blake & Loiselle (2000), point count surveys were used to sample the bird populations. Observers visited set points where they stood to listen and watch for the focus species as well as noting additional species. Volunteers are trained to recognise the calls and physical characteristics of the selected target species, as well as other species, in order to increase the accuracy of data collection during each survey. Each point count lasts 10 minutes at each of the marked points, including a minute settling period prior to starting. Points have been marked beforehand along each of the trails in the Osa project area using a handheld GPS. Points were selected in order to assess different habitat types, from primary forest to secondary regrowth clearings. Surveys are conducted in the morning, with the three point counts undertaken at 0530, 0600 and 0630am, to coincide with the dawn chorus. All birds seen or heard are noted down with particular attention paid on the six focus species highlighted above. The frequency of surveys is dependent on the number of other surveys in the wider Costa Rica project including otter, primate and turtle surveys detailed in this report, however a minimum of four a month will be conducted.

When noting down the species name and whether it is heard or seen, distance bands are also used in order to ascertain where the bird lies in relation to the trail. This will aid in establishing whether birds are found near or further away from man-made gaps in the forest various canopy layers. Distance band 1 encompasses a bird sighted, or heard, within 2 meters of the trail, band 2 is within 2 to 10 meters of the trail, and band 3 is beyond 10 meters. Figure 6 shows this in more detail.
3.6.3 Results and Discussion

Due to this project starting only very recently insufficient data has been gathered in order to present any graphical or statistical analysis. It is hoped in time graphical and statistical analysis can be carried out and reported.

Points of discussion are already present though from the pilot and current surveys. It is noted within the literature that even highly experienced observers can introduce a variety of bias into the results due to varying identification skills between species as well as differences in observation technique (Herzog et al. 2002). In order to avoid this, observer bias has been minimized with the same trail leader taking the survey each time. A new lead observer will be trained up to take over the project once they leave, and all volunteers are made familiar with the calls and physical characteristics of each of the target species before coming on a survey. The potential for the birds to have different calls from those that have been learnt using the recordings we possess, and use in our bird workshop training, is also an important point to recognise. Baldo & Mennill (2011) found that Great Curassow birds had many different calls and it is highly likely that the species under focus on this study also possess many variants of the calls learnt to identify them, potentially introducing error and the chance of missing certain birds whilst surveying the points. Due to the dense canopies overhead birds can also go unnoticed if they are not seen or heard, and heavy rain causes any survey to be cancelled as it becomes incredibly difficult to hear any birdcalls. With the dry season now beginning though it is hoped this won’t be such an issue going forward.

Future work will analyse differences between the different habitats encountered across the trails as well as elevation gradients. Human impacts will be analysed and it is hoped further surveys at
dusk can be undertaken to increase the survey effort. It is expected that this work shall be reported on phase CRF151.

### 3.7 CRF and the Osa Conservation Sea Turtle Conservation Programme

#### 3.7.1 Introduction

Sea turtles are a flagship species for conservation due to their iconic nature, and being an excellent indicator species for climate change. This is due to their temperature-dependant sex determination whereby increased temperatures create a sex bias skewed toward females, which could cause entire populations to collapse. Additionally, temperature-induced changes in plant community composition, together with rising sea levels, may result in increased incidences of beach erosion and inundation of nests (Janzen, 1994). Late maturation in conjunction with anthropogenic threats such as beach development, long line fishing and pollution mean that turtle populations are highly vulnerable and often unstable (Govan, 1998). Poaching, and the associated illegal trade of turtle eggs causes further reductions in turtle populations, which may result in entire clutches being destroyed. Turtle hunting was widespread between the 1950s and 70s with half of the world’s turtle catches being made in Mexico, where as many as 350,000 turtles were harvested annually (Marquez et al., 1996).

A number of conservation strategies have been established throughout Costa Rica, including limited legal commercial egg harvesting on a nesting beach in Ostional during the first 36 hours of wet season *arrribadas* (mass arrival of turtles) (Campbell, 1998), and an annual catch of 1,800 black turtles being granted to fishermen in Limón (Troëng and Rankin, 2004). Though the latter may have increased extractive use along with illegal hunting in the mid 1990s, the ban on black turtle fishing and increased law enforcement since 1999 may have increased female turtle survivorship (Troëng and Rankin, 2004). In other regions such as Tortuguero, the Costa Rican government has made egg poaching illegal, in addition to prohibiting the trade of calipee, the edible part of the shell (Government of Costa Rica 1963 and 1969; Troëng and Rankin, 2004). Meanwhile, the growing ecotourism industry in Costa Rica has provided locals with an alternative source of income and has promoted conservation throughout the country. To evaluate the effectiveness of such strategies, it is imperative that monitoring programmes are long term as it can take decades for species with late maturity to show a population response (Troëng and Rankin 2004; Bjorndal et al., 1999).

On the Osa Peninsula where turtles are threatened primarily from predation by dogs, coastal development, illegal trade of eggs and, to a lesser extent, turtle meat (Drake, 1996), NGO Osa Conservation have been patrolling Piro and Pejeperro beaches since 2003. Their aim is to monitor the frequency and health of the local nesting turtle population and manage nest relocations to the associated hatchery. The Frontier Costa Rica Forest research programme works in partnership with the Osa Conservation Sea Turtle Conservation programme protecting the four species which nest here: olive ridley (*Lepidochelys olivacea*), Pacific black turtle (*Chelonia mydas agassizi*), leatherback (*Dermochelys coriacea*) and hawksbill (*Eretmochelys imbricata*). The latter two rarely nest on these two beaches. The olive ridley is most commonly
found nesting here and is listed by the IUCN as Vulnerable whilst the black turtle is listed as globally Endangered (Troëng and Rankin 2004; Honarvar et al., 2008; IUCN, 2013).

3.7.2 Methodology

Now in peak olive ridley season, night and morning patrols were conducted on both Playa Piro and Playa Pejeperro, managed between Frontier and Osa Conservation. Morning patrols commenced at 04:00 am on Playa Piro and 03:00 am on Pejeporro (high tide permitting) to minimise surveyor exposure to direct sunlight and high temperatures. Night patrols typically started at 19:30 pm on both beaches. To minimise disturbance to nesting females, surveyors used red lights during night patrols and survey teams were limited to six people.

The survey area for both beaches was divided into 100 m sectors; this constituted a 2 km stretch of Playa Piro and 4.4 km stretch of Playa Pejeperro. For every turtle track encountered, data such as patrol date, name of data recorder, beach sector number and time were recorded. Nest data was also collected, for example; the nest type associated with the tracks (in situ IS, false crawl FC; i.e., turtle returned to sea without nesting or NA when the nest type could not be determined) and track symmetry (symmetrical S or asymmetrical A) and the nest distance to the vegetation. The track was then crossed through with a deep heel drag in the sand to avoid the track being recorded again in subsequent patrols. Track characteristics were used as an indicator of species where the turtle was absent (i.e., asymmetrical tracks suggest olive ridley, symmetrical tracks suggest black). If a turtle was encountered, the species and distance to the tide was recorded, a health assessment conducted and tagging of both the individual’s flippers completed.

In-situ nests were confirmed by inserting a stick into the sand to locate the egg chamber (indicated by a marked change in resistance when pressure applied) followed by careful digging to confirm the presence of eggs. A false crawl was defined by the absence of a nest or where it was clear that the turtle returned to sea without digging a nest. In the case of predated nests, typically evident by the presence of predator tracks, egg shells and signs that the nest had been dug up, the predator was identified by the tracks and number of egg shells recorded.

Flipper Tagging and Health Assessments

All turtles encountered pre- or mid-nesting were tagged whilst they were laying, during which time the female enters a haze and therefore associated stress is reduced. To reduce the risk of infection during tagging, the tag sites were washed firstly with water, then alcohol and iodine before applying the alcohol-cleaned tag. National’s ear tags (National Band and Tag Co., KY, USA), each with a unique identifying number engraved, were used. Two tags were used, one on each front flipper; both through the third nail from the body (Figure 7).
While the turtle was laying (or at latest when returning to the ocean, stopping the turtle en route by covering the eyes and kneeling in front of her), a health assessment was completed. In addition to the date, flipper tag number and beach sector number, the following health parameters were assessed; head (including the eyes, ears and nostrils), front and rear flippers, carapace and skin, fibropapillomas (e.g., barnacles) and body fat.

i) The features of the head are checked for swelling, cuts, lesions, sunken in eyes, wounds and other deformities.

ii) The flippers are checked for symmetry, wounds, deformities; such as missing digits, cuts, missing limbs, scars from tags torn out, and fibropapillomatosis, a form of the herpes virus which has a cauliflower-like appearance and may, in addition to being commonly found on the skin, be found on the eyes.

iii) The carapace is also noted for wounds, mating scars, boat strike wounds, defects and any exposed bones or flesh. Any epibionts such as barnacles, leeches and algae on the carapace are also counted.

iv) A body condition score is given, using integers from 1-3 where 1 indicates a thin and emaciated turtle and 3 indicates one which is overweight. The condition can most clearly be determined by inspecting the area around the neck and shoulder area.

Nest Triangulation

Nest triangulation was carried out only on those nests between sector 10 and 20 on Playa Piro for the close monitoring of individual nests and their respective incubation periods and hatchling success. When a nest was in situ the egg chamber was located through probing the sand with a stick, as above, and in effect a chimney was then dug to reach the surface of the eggs. In this chamber, a piece of flagging tape noting the date and a unique nest number to identify it was placed inside before the nest was covered again with the sand originally removed. From the point on the sand surface directly above the centre of the egg chamber, the
distance to the three nearest trees was measured, one central, i.e., approximately 90° relative to the nest, and one each to the east and west of this point. These trees were also marked with flagging tape noting the date, nest number and whether they are central (C), east (E) or west (W) of the nest. The height of the tape in the tree from the ground was also recorded for precise nest location referencing. Finally, the angle from the tree to the nest was recorded, again for C, E, and W.

_Nest Relocations and Hatchery Management_

Osa Conservation has restored the use of the hatchery to be included in the programme. Turtle nests that are at risk of flooding or erosion by the ocean’s tide are relocated to the hatchery. These were deemed to be found between sector one and 10 of Playa Piro. Considering this, the hatchery is located in sector 16 of Playa Piro. The hatchery is divided into 300 quadrats, lettered from A-O on one axis and 1-20 on the other. Each quadrat has a specific marker (e.g., A1, A2, and so on) in order to identify individual nests.

A maximum of three nests are to be relocated to the hatchery per day. Any additional nests may be relocated to sectors 11 and greater of Playa Piro, where they are not at risk of high tides. When relocations away from one of the at-risk sectors are necessary, but the time of day means that the ambient temperature becomes too high, or in the case that three nests have already been relocated to the hatchery that day, nests may also be relocated to these ‘safe’ sectors in order to avoid heat damage whilst transferring eggs.

When an _in situ_ nest is found, the first step is to locate the egg chamber by probing the sand. Next, wearing latex gloves, the surveyor digs out the eggs very carefully. Wet sand found in the nest is placed into a clean bucket, to provide cushioning for the eggs to be relocated. One by one the eggs are taken out of the nest and placed into the bucket, in the same upright position they were found in to avoid any damage to the embryo. The eggs are then covered by wet sand from the nest, again to avoid damage. The egg chamber’s depth and width are measured so that a new egg chamber, approximately identical in size and depth, can be dug during relocation. Date, sector in which the nest was found, number of eggs and time of relocation are to be noted on a ticket allocated to each nest, accompanied by the chamber measurements. Place of relocation is to noted on the nest ticket by circling either Relocated to A (hatchery) or B (other, e.g., sector 11). In either case, the egg buckets are carefully carried to their new location.

In the case of the hatchery, a pre-appointed quadrat is marked with red flagging tape by the previous surveyor, following a checkered pattern to allow space for working and for hatchlings between nests. The nest code (e.g., A1) is noted on the nest ticket, and all its information is transferred to a data sheet along with the time of arrival at the hatchery. A new egg chamber is dug, again whilst wearinglatex gloves, according to the measurements taken.

The sex of hatchlings has been shown to be determined by the temperature in the nest. Therefore, a plastic tube perforated with holes - to allow for air exchange, and long enough to reach the top of the nest - is inserted into the middle of the chamber of each new nest to house the thermometer inserted after egg deposition. This is in order to record temperatures in the nests and to estimate the percentage of male and female hatchlings at the end of the season. The
same process of transferring the eggs to the bucket is reversed to fill the nest. The wet sand from the bottom of the bucket is initially used to cover the eggs and is patted down. More wet sand is then used to cover the rest of the hole and patted down, and the remaining exposed pipe is covered with a bottle cap so that air exchange does not occur between the nest and the ambient air. Finally, a mesh is placed on top of the sand around the egg chamber. A ring around the nest is dug out to approximately 10cm depth to insert the bottom edges of the mesh. The top is tied with string in order to allow for easy opening when taking nest temperatures and to protect the nest from flies or predators. The red flagging tape is moved to the next quadrature to be used for relocation.

The temperature in each nest is to be checked three times per day: at 0600, 1400 and 2200 hours. Slowly, the thermometer is pulled out and the temperature read immediately, to allow for an accurate recording, before being carefully replaced in its original position. A rain gauge is also set up at the hatchery to be checked every morning at 0600, and emptied thereafter. Nest codes and temperatures (°C) as well as rain measurements (mm) are kept on a separate spreadsheet managed by Osa Conservation.

Whenever a surveyor visits the hatchery for temperature readings, all nests are checked for hatchlings that have emerged from the nest and are on the surface of the sand. When hatchlings are present, the nest code is noted and a total of 20 hatchlings are to be measured. The mesh is removed and with gloves the hatchlings are placed in a clean bucket. The mesh is replaced if any eggs or live pipped hatchlings remain in the nest. A clean Ziploc bag is clipped onto a handheld microscale (50g). The scale is calibrated to 0g. One by one a hatchling is placed in the bag and its weight noted. Next, the hatchlings’ carapace length and width is measured using a calliper and noted. Once all necessary hatchlings have been measured, they are replaced in the bucket and all are released on the beach. If the necessary number of hatchlings is not obtained from a single emergence, the next hatchlings to emerge from the same nest are measured until this number is obtained. This data is managed by Osa Conservation.

When relocating to sector 11 of Playa Piro, a new chamber is dug according to the measurements taken. Eggs are transferred from the bucket into the nest as described above as soon as possible to reduce any effect of egg temperature change whilst eggs remain in the bucket. This is particularly important during warmer hours of the morning. Once the chamber is full, wet sand from the bottom of the bucket is packed over the eggs, and the remainder filled with more wet sand. The nest is then triangulated according to the triangulation procedure above. No temperature measurements are taken for nests outside of the hatchery.

Nest Excavations

Triangulated nests are excavated after the expected hatch date to determine hatch success, emergence success and embryology, combining this data with the data collected at the time of nesting, and where possible linking with data of individual turtles (i.e., tagging and health assessment). These data are essential for quantifying hatching and emergence success, which are integral components in understanding population trends. Excavations, as described below, were also performed for non-triangulated nests when the hatchlings emerged; indicated by the presence of hatchling tracks or emerging hatchlings.
Any egg shells on the surface (greater than 50% of the entire shell) were counted and recorded as predated. The area was searched for any live or dead hatchlings outside of nests and these were recorded separately before beginning the excavation. If a live hatchling was found in the nest, it was removed and put on the surface of the sand to make its own way to the sea. The hatchling could be assisted by moving it closer to the sea if the sand was very hot, but as it is believed that for the hatchling to become imprinted on its natal beach to which it will return to nest as an adult (Lohmann et al., 2008), the hatchling must enter the water on its own. All of the remaining contents of the nest were removed separating unhatched eggs from empty egg shells. Unhatched eggs which varied from the normal white colouration and/or had large impressions present and were very soft-shelled were deemed dead - a lesson learned from years of professional experience gained by Osa Conservation and other expert parties - and were opened to ascertain the stage of development; white unhatched eggs were returned to the nest. There were five developmental stages which were determined by the percentage that the embryo occupied within the egg, graduated at 25% intervals whereby a Stage 1 occupied 0-25% of the egg (and had blood vessels and an eye spot present), Stage 2 occupied 26-50% and so on. The fifth category was for undeveloped eggs which were identified as an egg yolk with no signs of an embryo or eye spot. Protective latex gloves were worn at all times.

3.7.3 Results

The table below shows the data collected between the 22nd September and the 06th December 2014. A total of 36 patrols were conducted by Frontier staff, 16 on Pejeporro and 20 on Piro. In this period Frontier and Osa Conservation staff encountered 548 tracks on Pejeporro beach and 342 tracks on Piro beach, with *Lepidochelys olivacea* encountered and tagged more than *Chelonia mydas Agassi* on both beaches (Table 7).

**Table 7:** Summary of all turtle data collected between 22nd September and 06th December 2014. LO: *Lepidochelys olivacea*; CM: *Chelonia mydas agassiz*; S: symmetrical tracks; AS: asymmetrical tracks.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Piro-LO (AS)</th>
<th>Piro- CM (S)</th>
<th>Peje- LO (AS)</th>
<th>Peje- CM (S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total no. turtles tagged</td>
<td>21</td>
<td>7</td>
<td>59</td>
<td>31</td>
</tr>
<tr>
<td>Total no. tracks</td>
<td>239</td>
<td>103</td>
<td>526</td>
<td>422</td>
</tr>
</tbody>
</table>

A 10 week study conducted by a BTEC student, Philip Cliff, on the levels of nest predation by animals on Pejeporro and Piro beach showed that predation was most prevalent on Piro beach (62%) compared to Pejeporro (38%), with the white-nosed coati being the animal most responsible for predation, at 41% (Fig. 7a). A high percentage of predation (38%) was caused by an unknown animal. This generally meant that the nest was open and predation was visible, but the predator left not indirect evidences for identification such as tracks.
If we compare Philip’s study with a similar study on predation in the area carried out in 2011 (Fig. 7b), we can observe similar levels of unknown predation, 38% and 32% respectively. In contrast, since 2011, there has been a decrease in dog’s predation of 44% but an increase of 31% in coati’s predation. There were no accounts for racoon predation in the previous study.

3.7.4 Discussion

Consistent with the peak nesting seasons of marine turtles in the study area, there were a greater number of L. olivaea encountered on both beaches. The intensity of tagging has been more significant in this phase, owing to management of the programme by Osa Conservation leading to increased night patrols. An increased proportion of tagged turtles will help the project
progress towards the aim of estimating population size by capture-recapture analysis and also to monitor the health of individual turtles through recaptures.

Due to its greater length, Playa Pejeperro has more suitable nesting sites available than Playa Piro, which is considerably shorter. Nevertheless, Playa Piro is wider and therefore more suited to *L. olivacea* because of the larger area of sand. Whereas the narrower Playa Pejeperro has much more vegetation, so the *C. m. agassiz* prefers to nest near to or within this (*Bjorndal et al.*, 1999; *Turkozan et al.*, 2011).

There has been an increase in predation by coatis on both beaches; this is possibly related to the high tides experienced in the past months. High tides exposed the newly laid nests, which became easy targets for coatis and subsequently for other animals such as vultures.

Philip’s study reported that the levels of predation in Piro have been higher than those of Pejeperro for this phase which correlates with the peak breeding season of the Olive Ridley and the fact that this species prefers to nest in Piro beach. Coatis are currently the biggest threat to nests on both beaches, particularly in Piro. Piro’s vegetation is wider and connects with secondary and primary forest whereas Pejeperro’s vegetation is fragmented by agricultural and farm land making more difficult to sustain large coati’s populations.

Data from 2011 showed a significant decrease in dog predation, especially in Pejeperro, suggesting that the abandonment of the house at sector 24 on Playa Pejeperro, which contained up to 23 dogs at times, has had lasting effect on the significant reduction of nest predation.

In the next phase Frontier’s collaboration with Osa Conservation will continue to manage daily morning and night patrols of both beaches and it is anticipated that in CRF151 we will be reporting on the hatching success from the hatchery.

### 3.8 Identification of Mammal Tracks within the Osa Conservation site at Piro.

#### 3.8.1 Introduction

Costa Rica provides a home for more than 200 mammal species including: 3 species of anteaters, 2 species of sloth (*Bradypus variegates* and *Choloepus hoffmmani*)), many large rodents such as the Agouti (*Dasyprocta punctata*) and Paca (*Agouti pacas*), and other large sized mammals such as the Baird’s Tapir (*Tapirus bairdii*) (*Wainwright & Arias*, 2007). Six species of felines are also native to Costa Rica, Jaguar (*Felis Onca*), Puma (*Puma concolor*), Ocelot (*Leopardus pardalis*), Jaguarundi (*Puma yagouarouendi*), Oncilla (*Leopardus tigrinus*) and Margay (*Leopardus wiedii*); all species expect for the Oncilla, that inhabits premontane and cloudy forests, can be found in the Osa Peninsula (*Cavalcanti & Gese* 2009). Across the focal species’ distribution range, the only species listed by the IUCN (2014) as ‘endangered’ is *Tapirus bairdii*, however, many others are listed as globally ‘vulnerable’ or ‘near threatened’ and throughout their Costa Rican range, all feline species,
Lontra longicaudis and Tayassu pecari are also considered to be highly endangered (Cavalcanti & Gese 2009) (Table.8).

Despite protective legislation, human-wildlife conflict is common throughout Central and South America (Zimmermann et al. 2005), as prime wildlife habitat continues to be converted for agricultural use and resource extraction (Cavalcanti & Gese 2009). Estimating the distribution and abundance of mammals, particularly wild living cats, is difficult. This is especially the case in this area of Costa Rica, as populations are extending their range from Corcovado National Park and along the biological corridor to other reserves within the Osa Peninsula, making it even more vital to effectively conserve and manage the area. Information on distribution is also vital for the introduction of education and awareness initiatives, with the aim of preventing human-wildlife conflict that threatens mammal populations and livelihoods across the species range (Zimmermann et al. 2005).

Many mammals are shy and elusive creatures, and, their adaptation to life in the undergrowth or canopy, or nocturnal lifestyle makes detection difficult. Over the years, wildlife biologists have used various tracking techniques to assess mammal populations. The most common method is to detect the tracks left in fine soil or sand (Olifiers et al., 2011). This method is also used in the present study to investigate the abundance and distribution patterns of medium and large mammals within the Osa Conservation site at Piro.

### 3.8.2 Methodology

Track searches were performed along the existing trails and beach trails (Piro and Pejeperro) within the property at 7:00 am to prevent tracks from fading. Table 8 includes the names of the 19 targeted species. All tracks were recorded including measurements of the track at its widest point and the vertical distance from the toes to the palm pad (Fig.8). GPS position was noted only when a wild cat track was encountered. Three considerations were taken into account when recording tracks; (1) Some species such the Margay are arboreal therefore tracks are seldom encountered (2) Tracks for the same species were only recorded if they were 100 m apart or if they were situated in a different direction to prevent overestimation; (3) When the trail was crossed by a body of water, tracks were recorded within a 5 m radius of the trail (Olifiers et al., 2011; Kappelle et al., 2003). Due to the leaf composition of tropical forest ground, there is a considerable level of skill necessary in accurately detecting and identifying tracks. The mammal track workshop includes training to enable staff and volunteers to become familiar with target species tracks, making data collection as effective as possible.

<table>
<thead>
<tr>
<th>Species Name</th>
<th>Latin name</th>
<th>IUCN Status</th>
<th>Costa Rica Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baird's Tapir</td>
<td>Tapirus bairdii</td>
<td>Endangered</td>
<td>Endangered</td>
</tr>
<tr>
<td>Collared peccary</td>
<td>Pecari tajacu</td>
<td>Least Concern</td>
<td>Least Concern</td>
</tr>
<tr>
<td>Species</td>
<td>Scientific Name</td>
<td>Status</td>
<td>Status</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>------------------------------------</td>
<td>-----------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>White-lipped peccary</td>
<td><em>Tayassu pecari</em></td>
<td>Vulnerable</td>
<td>Endangered</td>
</tr>
<tr>
<td>Red brocket deer</td>
<td><em>Mazama Americana</em></td>
<td>Data Deficient</td>
<td>Data Deficient</td>
</tr>
<tr>
<td>Tayra</td>
<td><em>Eira Barbara</em></td>
<td>Least Concern</td>
<td>Least Concern</td>
</tr>
<tr>
<td>Neotropical Otter</td>
<td><em>Lontra longicaudis</em></td>
<td>Data Deficient</td>
<td>Endangered</td>
</tr>
<tr>
<td>Striped hog-nosed skunk</td>
<td><em>Conopatus semistriatus</em></td>
<td>Least Concern</td>
<td>Least Concern</td>
</tr>
<tr>
<td>Common opossum</td>
<td><em>Didelphis marsupialis</em></td>
<td>Least Concern</td>
<td>Least Concern</td>
</tr>
<tr>
<td>Water opossum</td>
<td><em>Chironectes minimus</em></td>
<td>Least Concern</td>
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</tr>
<tr>
<td>Northern tamandua</td>
<td><em>Tamandua Mexicana</em></td>
<td>Least Concern</td>
<td>Least Concern</td>
</tr>
<tr>
<td>White-nosed coati</td>
<td><em>Nasua narica</em></td>
<td>Least Concern</td>
<td>Least Concern</td>
</tr>
<tr>
<td>Crab-eating raccoon</td>
<td><em>Procyon cancrivorus</em></td>
<td>Least Concern</td>
<td>Least Concern</td>
</tr>
<tr>
<td>Central American agouti</td>
<td><em>Dasyprocta punctata</em></td>
<td>Least Concern</td>
<td>Least Concern</td>
</tr>
<tr>
<td>Paca</td>
<td><em>Agouti paca</em></td>
<td>Least Concern</td>
<td>Least Concern</td>
</tr>
<tr>
<td>Nine-banded armadillo</td>
<td><em>Dassypus novemcinctus</em></td>
<td>Least Concern</td>
<td>Least Concern</td>
</tr>
<tr>
<td>Puma</td>
<td><em>Puma concolor</em></td>
<td>Least Concern</td>
<td>Endangered</td>
</tr>
<tr>
<td>Ocelot</td>
<td><em>Leopardus pardalis</em></td>
<td>Least Concern</td>
<td>Endangered</td>
</tr>
<tr>
<td>Jaguarundi</td>
<td><em>Puma yagouaroundi</em></td>
<td>Least Concern</td>
<td>Endangered</td>
</tr>
<tr>
<td>Margay</td>
<td><em>Leopardus wiedii</em></td>
<td>Near Threatened</td>
<td>Endangered</td>
</tr>
<tr>
<td>Jaguar</td>
<td><em>Panthera onca</em></td>
<td>Near Threatened</td>
<td>Endangered</td>
</tr>
</tbody>
</table>

**Figure 8:** Standard measurements taken: A- Track widest point and B- vertical distance from the toes to the palm pad.

### 3.8.3 Results and Discussion

Although this project was recently started it has already yielded its first results, and from the 22nd of September to the 15th of December we have encountered 97 tracks from 10 different species, including two Jaguar tracks. Table 9 summarises the number of mammal tracks per species encountered in different trails within the Piro Property. Agoutis were the most common
tracks recorded (43) in all trails surveyed, particularly around secondary forest habitats such as Ocelot, Beach Trail, Caracol Trail, and Ajo Trail. In the past, agoutis were an important food source for man throughout their range, and although the meat was not generally considered as desirable as that of their nocturnal relative the paca, they were more abundant and easy to catch which led local populations to collapse (Kappelle et al., 2003; Smythe, 1978). In spite of this, in the few remaining neotropical lowland forests that have not been severely disturbed by man, such as Corcovado National Park, populations keep thriving and agoutis remain the most commonly observed diurnal terrestrial mammal (Kappelle et al., 2003; Smythe, 1978). Additionally, agoutis are associated with primary and secondary forest and scrub, requiring some dense vegetation for cover, but often preferring open areas for foraging, which is also suggested by these results (Kappelle et al., 2003).

### Table 9: Number of mammal track encountered in beach trails and trails around Piro Station.

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>TRAIL NAME</th>
<th>Ajo</th>
<th>Beach</th>
<th>Caracol</th>
<th>Ocelot</th>
<th>Pejeporro</th>
<th>Piro</th>
<th>Grand Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agouti</td>
<td></td>
<td>18</td>
<td>8</td>
<td>9</td>
<td>8</td>
<td></td>
<td></td>
<td>43</td>
</tr>
<tr>
<td>Coati</td>
<td></td>
<td>3</td>
<td>3</td>
<td></td>
<td>11</td>
<td>9</td>
<td></td>
<td>26</td>
</tr>
<tr>
<td>Jaguar</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Jaguarundi</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Margay</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Ocelot</td>
<td></td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Peccary</td>
<td></td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td></td>
<td></td>
<td>11</td>
</tr>
<tr>
<td>Puma</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Raccoon</td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
<td>3</td>
<td>2</td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>Skunk</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td></td>
<td>24</td>
<td>14</td>
<td>21</td>
<td>10</td>
<td>15</td>
<td>13</td>
<td>97</td>
</tr>
</tbody>
</table>

White-nosed coatis and crab-eating raccoons are omnivorous, and locally their diet typically consists of fruit, invertebrates, crabs, and turtle eggs, which they locate with their formidable sense of smell and dig out with their sharp claws (Wainwright & Arias, 2007). In accordance with this, our results show that coatis and raccoons prefer secondary forest habitats close to their feeding grounds, such as Beach Trail and Caracol Trail, and Pejeporro and Piro where surveys were carried out on the sand along the shore.

Feline tracks were found mainly in three trails Piro, Pejeporro and Caracol Trails. The most recorded track belonged to an Ocelot (*Leopardus pardalis*), followed by Puma (*Puma concolor*) and Jaguar (*Panthera onca*). Jaguarundi (*Puma yagouaroundi*) and Margay (*Leopardus wiedii*) tracks were only encountered once. The numbers of wild cat tracks observed in the studied area, especially from jaguars, in such a small period of time, is very encouraging and suggests that numbers of felines are increasing around Piro Station, however, more data collection and subsequent analysis would be required to draw further conclusions.
4. Additional Projects

4.1 Assessing River water quality and macro invertebrate’s diversity and abundance in Piro Piro and Quebrada Conyunta.

Analysing the quality and levels of macro invertebrates and bacteria in the rivers offers valuable data for research, assessment, regulation, and environmental impact studies. Through using river data collected by the local community at Piro and other areas of the Osa Peninsula, and increasing public awareness and engagement, we hope in time to build a Water Atlas for the protection, conservation, and management of the Osa Peninsula rivers.

Points along the two rivers within the Piro Property are selected and Leaf Packs are utilised to sample populations of macro invertebrates. Leaf Packs is a hands-on scientific stream-testing kit that measures the numbers and species of insects and other invertebrates in streams to determine overall water quality. It also enables local members of the community to explore nature as they learn about stream ecology and how to monitor their local freshwater sources. Collecting data is very easy and volunteers are trained to recognise main macro invertebrate morphological features. Volunteers filled the mesh bag contained in the leaf pack with dry leaves and placed the pack in the stream for three to four weeks. Then, the pack is examined and aquatic macro invertebrates are identified and counted. Other water analysis such as water turbidity, pH, levels of oxygen, and level of e coli bacteria are also carried out once a month. Monitoring the streams and macro invertebrates for changes over time could indicate any future problems within their ecosystem.

It is expected that this work shall be reported on in phase CRF151.
5. Proposed Work Programme for Next Phase

Primate surveys will continue, sampling evenly across old and new trails and times of day until sufficient data is collected for all four primate species. It is expected that in phase CRF 151 or 152, it will be possible to report on squirrel monkey and capuchin density and that these results will be prepared for peer-reviewed publication as with the recent research article on spider monkey and howler monkey density. Primate behaviour will also continue to investigate the behaviours of monkeys in Piro trails and is expected to be reported next phase.

An additional primate study will also start next phase. Local primate populations are habituated to human presence due to the long term presence of researchers at and tourists to the area. This new project will compare data obtained from regular primate surveys which include two surveyors (i.e. one Frontier staff and one volunteer) with primate surveys containing 5 and 6 surveyors (i.e. one Frontier staff and 4-5 volunteers). Finding out that there is no difference on the data collected when the number of volunteers is increased, could have significant implications for the number of volunteers that could carry out the survey at once.

The *in-situ* otter project will continue until there is sufficient data to analyse. This will provide a greater insight into the ecology of the species. In the next phase it is anticipated that the *ex-situ* project will make considerable progress (See section 3.4 for more details on using camera traps to estimate species abundance of otters).

Turtle patrols will continue at approximately the same frequency and we will continue to work with Osa Conservation on the programme. CRF also anticipates further investigation of the predation on marine turtle nests. This will involve using historical data and new data from day patrols in phase CRF151 onwards.

The bird project will carry on collecting point count data to analyse between different types of habitats encountered across the trails as well as elevation gradients.

The butterfly project is expected to resume in phase 151 after a long rainy season. This project was suspended during phase CRF142 owing to weather conditions; regular high rainfall would significantly hinder the project and deem it impractical. There are also ethical considerations as trapping butterflies in heavy rainfall may results in fatalities.
6. References


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