Calakmul is a large expanse of tropical forest that is continuous with the Maya Biosphere Reserve in the Petén Province of Northern Guatemala. Calakmul biosphere reserve covers an area of 723,000 hectares, but is attached to two state reserves Balam-kim and Balam-ku which run the entire length of the western side of the biosphere. The total area covered by these connected reserves is 1,200,000 hectares, but these reserves are surrounded by more forest giving rise to over 4 million hectares of forest. Over 20,000 people live in and around Calakmul and with more people moving into the area, developments are starting to affect the landscape and hunting rates. Hunting is reported to affect ranging patterns of forest ungulates in the reserve (Reyna-Hurtado & Tanner, 2005). However, the most notable change is the development of the main highway that bisects the northern and southern parts of the reserve. This road development is already reported to affect ranging patterns of jaguar (Colchero et al., 2011), but the effect on other species is not well known.

Large mammal density at Calakmul Biosphere Reserve is very high and the forest is one of the last remaining strongholds of endangered mammals such as jaguar and tapir. The tropical semi-deciduous forest in Calakmul Biosphere Reserve is unusual in that areas close to Mayan Ruins contain unusually high densities of large fruiting trees (the result of Ancient Mayan agro-forestry) in comparison to other areas (Ross & Rangel, 2011). As there are no rivers or streams in the reserve, forest structure is also heavily affected by distance from the few permanent water sources in the reserve known as aguadas. In addition, there is a steady increase in mean annual precipitation from the north to the south of the reserve that has a notable effect on tree species composition and forest structure.

The aim of the large mammal research project is to investigate the relationship between habitat characteristics and large mammal abundance and ranging. The project also aims to provide reliable estimates of population density by collecting data in different sections of the forest with and without aguadas and ruins. Projects can focus just on primates and terrestrial mammals or just one of the two. Projects focussed on terrestrial mammals may chose to focus on certain species such a tapir that are known to adjust their range according to proximity to water, or large predators (eg. jaguar and puma) and their prey (peccary and deer).

**Methods**

Data collection will be carried out in 5 different locations with the Calakmul Biosphere Reserve (Figure 1). These camp locations have been chosen due to their accessibility during the wet season and because they cover the full geographical and vegetation range of the reserve. Each camp will contain four 2km long transect lines for data collection that have been mapped using a GPS unit. Five sample sites for habitat surveys will be located along each transect line at 500m intervals, giving rise to 100 sample sites across the 5 research camps in the reserve. Each sample site will consist of a 20m x 20m area adjacent to the transect line. These sample sites will be marked and the GPS location recorded.
Primates and large terrestrial mammals will be surveyed along line transects (that are not placed with any pre-determined knowledge of the distribution of the animals: Peres, 1999), using distance sampling (Buckland et al., 2001). The entire length of the transect line will be walked by small groups of 3-4 observers walking quietly and slowly (500-1,000 m/hr), starting at 6.30am when the majority of animals are most active and are easiest to detect. Each time an animals is encountered the species, whether the animals was seen or heard, number of individuals (visual sightings only), perpendicular distance from the individual to the transect line, habitat, time, distance travelled along the transect line and weather conditions will be recorded. Each transect line must be surveyed on four separate occasions.

The distance sampling method is only suitable when animals are relatively easy to detect and is therefore unsuitable for monitoring elusive species living a low densities such as jaguar. Thus, an additional two methods will be used to monitor these species: patch occupancy sampling (Mackenzie, 2005) and camera trapping. Patch occupancy sampling involves detecting animals based on tracks and faeces rather that visual or vocal sightings of the animals. These data will be collected as students walk back along the transect line to camp (i.e. after the distance sampling). Camera traps that belong to the reserve will be placed in areas of the forest, close to some of the research camps, but in areas that will not be visited by human observers conducting survey work. It will therefore be possible to compare density estimates from transect surveys with density estimates from camera
traps, but as the camera traps are part of a different ongoing study, it is not possible to change to location of the traps to better suit individual projects.

Habitat surveys will be conducted in each of 20m x 20m survey sites to investigate tree diversity and basal area, and to estimate carbon tonnage within the reserve. Surveys will generally be conducted in the afternoons. Numbered metal tags will be attached to each tree in the plot, and the species, DBH, height of each tree, and whether the tree is alive or dead will be recorded on datasheets with the corresponding tree tag number. Where species cannot be identified in the field, photographs of leaves, fruit (if available leaves and bark will be taken for later identification from textbooks. If identification is not possible from photographs, then samples may be taken from the tree at a later date for full examination. DBH will be measured using 50m tape measures and tree height will be calculated using laser range finders (tree height can be estimated based on the distance of the observer from the base of the tree and the angle from the observer to the top of the tree).

Large mammal data from each transect can then be related to mean habitat characteristics for the transect line and comparisons between mammal abundance and habitat variables may be investigated. Alternatively, mammal ranging data (i.e GPS readings for each encounter) can be uploaded to digital maps of the reserve using ArcGIS and ranging patterns investigated in relation to mean annual temperature, rainfall and vegetation type.

Suggested Reading


