IWOKRAMA INTERNATIONAL CENTRE FOR RAIN FOREST CONSERVATION AND DEVELOPMENT

Iwokrama Baseline and Monitoring report

Monitoring, Resource Management and Training

GSI Phase II – funded by European Commission and implemented thorough UNDP with technical support from IUCN-NL and Sarvision

May 2010

1. Introduction

In August 2008, Iwokrama International Centre (IIC) signed two contracts with the UNDP to implement a project titled 'Ecological and sustainable management of the Guiana Shield Eco- Region. Iwokrama was designated the pilot site for Guyana. One contract dealt with supporting and developing the monitoring programme within the Iwokrama Forest on the premise that if ecosystem services are to be sold in the future, the provider must ensure that these services are being maintained.

The main objectives in the contract related to:

- The preservation of the biodiversity in relation to the management of the site
- Climate regulation, the preservation of carbon stock of the site and the sequestration of carbon dioxide by the forest of the site
- The maintenance of the hydrological services provided by the site (quality and quantity of surface and ground waters); contributions through evapotranspiration.

An initial assessment of the existing monitoring programme with Iwokrama staff, the Pilot Project Coordinator (UNDP) and technical experts from the IUCN-NL and indicators for assessment were added to Iwokrama's existing monitoring framework to fulfil the needs of the contract.

Three primary ecosystems services are identified (biodiversity, freshwater, and climate regulation) in order to monitor changes in the Iwokrama ecosystem, and also the impacts of human induced pressures, particularly sustainable resource use as a form of conservation management. Pressures acting upon ecosystem services at Iwokrama are monitored through four landscape level target areas; forest (including forestry), road, river and climate. Within each of these target areas, methods which are logistically and financial viable are implemented in order to provide consistent long-term datasets which can answer specific monitoring questions.

The goal of this monitoring programme is to monitor the status and trends of key ecosystem services, and identify areas or species that could be adversely affected by anthropogenic activities. These data are subsequently used in management decisions to endeavour to mitigate adverse impacts and reconcile the causal activities.

Figure 1.1 displays the decision making process utilised during the design of an effective monitoring system. At Iwokrama it is especially necessary to identify target components in order to effectively monitor pressures acting upon ecosystem services.

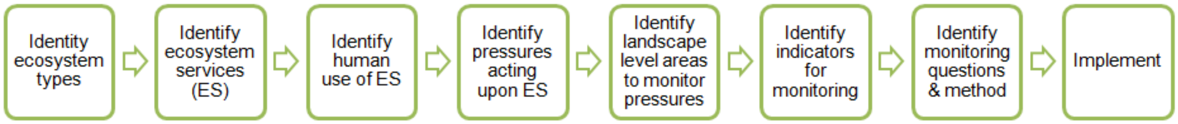

Figure 1.1. Decision making process utilised during the design of Iwokrama's monitoring programme.

To enable the effective design of a monitoring programme, focused questions must be asked. This is because unspecific monitoring of habitats or species can rarely provide insight into the modifications caused by the primary influential factors, i.e. human activity. It is therefore necessary to identify potential pressures, in order to monitor the health of Iwokrama's ecosystem services, and subsequently target questions at the responses to these pressures of biological and physical parameters. The pressures which form the survey questions within Iwokrama include timber harvesting, mining, road traffic, hunting, fishing, small scale deforestation (by the Fair View community), tourism, climate change, research and monitoring, and waste. Additionally, natural fluctuations of ecosystem mechanisms represent pressures, and are therefore monitored with relation to temporal variability.

Under many circumstances, biodiversity is monitored in order to quantify impacts, and the maintenance of ecosystem services. This is because plants and animals represent some of the best indictors of ecosystem quality, as they are often susceptible to changes in the environment. This framework identifies biodiversity that are not only potential indicators, but are also easily and cost effectively monitored. Practicality is essential when designing these protocols, as they must be realistic to represent a template for comparable initiatives elsewhere, and implementable during times of financial hardship.

Target components and landscapes are identified in order to benefit monitoring logistics. Road, river, forestry, remote sensing and climate cover the range at which the multi-level monitoring operates.

Table 1.1 identifies the primary pressures faced and indicators selected on which monitoring was done.

Table 1.1 Ecosystem services, identified pressures, and landscape level target areas for monitoring and their monitored indicators with basic methods. (from Iwokrama's Monitoring Framework)

Ecosystem service	Primary pressures	Target components/landscapes for monitoring	Indicator/focus	Monitoring method
Biodiversity - *fauna* - *flora*	Timber harvesting Road Mining Hunting	Forestry Road River	Birds Bats Large mammals plants	Monitoring of key plant and animal taxa as they respond to pressures – transects, point counts, mist-netting, permanent sample plots

Freshwater *- quality* *- quantity*	Mining Timber harvesting Climate change	River Forestry Remote sensing	Water quality - Otters - Waterfowl Water quantity	Quality - Analysis including pH, dissolved oxygen, turbidity, micro-bacteria. Birds and otters used as additional indicators of river quality. Quantity - Hydro-meteorological stations which provide data on short and long-term variation in water parameters such as discharge and height.
Climate regulation 1. *- Carbon sequestration*	Climate change Timber harvesting Deforestation	Forestry Remote sensing	Carbon stocks per vegetation type	Permanent Sample Plots (PSP's), which record growth and yield of forest in response to biophysical parameters, and pressures. Additionally, forest cover through remote sensing to provide data on overall land cover.
Climate regulation 2. *- Adaptation to climate change*	Climate change Natural fluctuations	River Weather Forest phenology Remote sensing	Rainfall Temperature Humidity River dynamics Phenology	Hydro-meteorological stations which provide data on short and long-term variation in climate, and river dynamics. Changes in plant phenological cycle quantified to provide information on fluctuations in climate and plant adaptation.

2. Carbon sequestration

2.1 Carbon stock assessment

Carbon Stock

The estimated total carbon found in the Iwokrama Forest was 115.7 Mt. (Ter Steege 2001). Thi was based on the total carbon stocks of the Iwokrama Forest using forest inventory data to determine forest types and areas (see Table 2.1).

Table 1.1 : Forest types and estimated carbon stocks (Table 8 from ter Steege, 2001)

Forest type	Area (ha)	Carbon (t ha^{-1})	Mt Carbon
Mixed forest on flat terrain	170,120	334	56.8
Mixed forest along rivers	4,997	334	1.67
Liane forest	1,736	250	0.43
Liane forest on sandy terrain	42,479	250	10.62
Liane forest on steep high hills	89,132	286	25.49
Wallaba forest on white sand ridges	7,085	306	2.17
Wallaba-Dakama forest	3,503	200	0.7
Dakama-Muri Scrub	7,431	67	0.5
Low swamp forest	2,975	400	1.19
Mora forest	13,324	374	4.98
Marsh swamp forest	11,665	374	4.36
Mixed swamp forest	274	334	0.09
Swamp-Wallaba forest	16,582	400	6.63
Clearings	42	0	0
Totals	371,345		115.66

The Ecosecurities report (2009) estimates that pre-harvesting carbon stocks in the Iwokrama Forest roughly adds up to 116 million tonnes of C. The study also estimated that the planned timber sustainable harvesting model would lead to a net loss of 581, 745 tC at full capacity.

3 Climate regulation and Hydrology

3.1 Climate regulation and hydrology

Hydrometeorological instrumentation is a critical component of climate and hydrology monitoring and supports all research related to the water cycle with climate as a key driver. Establishing a baseline understanding of the climate and water-cycle is vital for sustainable forest management, assessments of forest ecosystem services in support of payment mechanisms, biodiversity, carbon capture and storage, ecology and impacts on human populations amongst others.

A new hydro-climate instrumentation program which has recently been established in Iwokrama is designed to provide baseline datasets for a variety of applications. Newcastle University is partnering with Iwokrama on this monitoring project with main funding from IDB. The set-up is also designed to anticipate varied possible uses for long-term research. This project nicely compliments the GSI project.

Specifically, the strategy is based on the following concepts:

- **Quantifying rainfall and evapotranspiration budgets at different timescales**
  The primary aims of the meteorological instrumentation are to provide baseline datasets which can help to quantify the rainfall and evapotranspiration components of the water balance for the Iwokrama rainforest reserve, and to characterise the rainfall inputs at storm, seasonal, and inter-annual timescale.
- **A transect through the climate transition zone**
  Previous studies on regional climate patterns (specifically, a project recently completed by Newcastle University to collate and interpret climate data for the region[1]) indicate that Iwokrama is located at a key transition zone between the coastal-influenced climate with higher annual rainfall and two wet seasons, and the drier continental climate typically with a single wet season. The Rupununi savannah area to the south of Iwokrama also provides an interesting hydrometeorological contrast. The instrumentation is intended to characterise these transitions in more detail, taking a north-south transect through the transition zone.
- **Characterising hydrological response of the landscape**
  The diverse landscape of the Iwokrama forest reserve is characterised by spatial variations in geology and soils, topography, and vegetation types. This diversity leads to different types of hydrological response, with consequences for other aspects such as nutrient cycling and erosion, so one aim of the hydrological instrumentation is to select locations that can support monitoring of these different responses.
- **Characterising forest management impacts**
  A key aspect of studies at Iwokrama is to understand the impacts of sustainable forest management. Based on the historical and planned forest harvesting

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[1] Bovolo C. I., Parkin G., Wagner T. (2009) *Initial Assessment of the Climate of Guyana and the Region with a Focus on Iwokrama.* School of Civil Engineering & Geosciences, Newcastle University, Newcastle upon Tyne, UK

programme, catchment monitoring locations have been selected to represent different stages in the harvesting cycle.

Monitoring Sites

The instrumentation program comprises:

- two fully automated weather stations (including raingauges and evaporation pans), operating at the Iwokrama Centre and Bina Hill Institute (Annai);
- three additional automated tipping bucket rain gauges located at Turtle Mountain and along the forest road;
- two automated water quality monitoring probes;
- five locations on creeks where river levels are constantly recorded.
- Two separate portable field devices (an ADCP sonar system and a current meter) are also available to measure river flow rates, and a hand-held probe to measure water quality.

The rationale for choice of site locations is:

- The two AWS sites at Iwokrama field station and at Bina Hill Institute provide the end members of the climate transition from the forest to the savannah climate zones
- The set of rain gauges (including tipping bucket rain gauges and storage rain gauges) from Iwokrama to Bina Hill provides further detail on the climate transition, as well as providing more detailed sampling of the spatial variability in convection-dominated rainfall, and providing localised rainfall associated with the catchment hydrological studies
- The rain gauge at Turtle Mountain is located at a higher elevation, providing some local information on elevation-dependence of rainfall amounts
- The stream flow monitoring locations combined with the water quality continuous monitoring at Tiger Creek and at Blackwater Creek, provide information on an already harvested catchment area and a non-harvested catchment respectively. The stream flow monitoring location at 8-mile Bridge represents a catchment area which is not yet harvested, but is planned to be harvested within a year or two of installation.
- The stream flow monitoring locations at Tiger Creek, 8-mile Bridge, and Blackwater Creek are all located in catchments on similar landscape types with low nutrient status permeable sandy plains and terraces, low topographic variation, and similar forest types. The other two stream monitoring locations at 38-mile Bridge and Kuipari represent different landscape types, receiving water from steeper sloped shallow acidic soils, and thin nutrient-poor clay-loam soils, of steep catchments in the Iwokrama Granite Massif. They also represent the southern end of the climate transect across the Iwokrama reserve.

Table: Hydro-meteorological instrumentation at Iwokrama with final installation dates

Location	Automatic weather station (incl. evap pan)	Tipping bucket raingauge	Storage raingauge	Stream flow gauging station	Stream water quality
Iwokrama field station	✓ 10-04-10	✓ 26-03-10	✓ pre-existing		
Turtle Mountain		✓ 04-04-10			
Tiger Creek (near 3-mile Bridge)				✓ 04-04-10	✓ 04-04-10
Tiger Woods timber site (TGI)		✓ 29-03-10			
8-mile Bridge				✓ 18-03-10	
Blackwater Creek				✓ 18-03-10	✓
Big Turu Creek				✓ 17-03-10	
Kuipari Creek				✓ 17-03-10	
Canopy walkway		✓			

		30-03-10			
Ranger Station 2			✓ pre-existing		
Bina Hill	✓ 06-04-10	✓ 06-04-10	✓ to be installed		

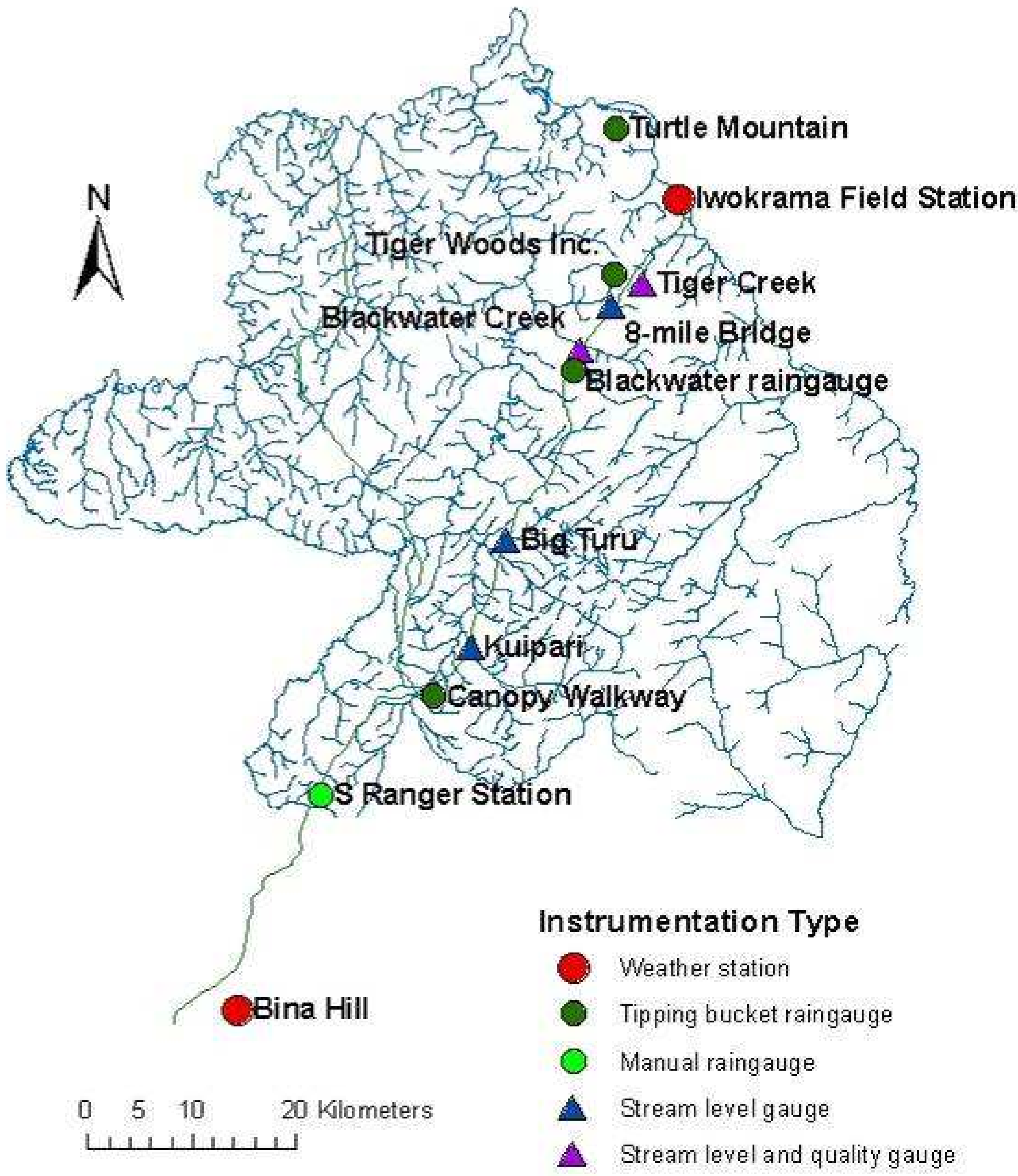


Figure 2.1 Hydro-meteorological instrument locations.

Photo: Iwokrama Field Station Automatic Weather Station (centre back) with tipping bucket raingauge and evaporation pan (right), older manual raingauge (centre front) and older casing for manual humidity and temperature sensors.

Initial Results

Automatic Weather Station

Initial results are only available from the Automatic Weather station at Iwokrama. These are shown below.

Figure shows solarimeter measurements (incoming and reflected radiation from the sun), pressure, humidity and air temperature and hourly and daily precipitation totals. The results are shown for one month. The data gaps are due to the unit being switched off during final installation.

At the Iwokrama field station for March-April 2010, Nett solar radiation has reached over 650 W/m^2 but generally tends to be about 450 W/m^2. Pressure varies between 1009 and 1001 mb and is lowest during precipitation events. Humidity and Temperature are highly correlated. Temperature varies between 22 and 34 degrees and the temperature is overall much lower during a precipitation event. Humidity is generally around 50% during the day but reaches 95 % at night. Precipitation events cause humidity to rise significantly. Over the short test period, daily (midnight to midnight) precipitation reached about 60mm/day whilst 5 minute intensities reached 25mm/hour.

The data can also be examined for daily cycles (Figure). Humidity over the period is generally very high at night but drops rapidly from about 7am reaching is minimum at about

3pm before rising again at night. Where the humidity is particularly high during the middle of the day, this is caused by precipitation events. Temperature is generally quite steady during the night but rises rapidly from about 7am, again peaking at about 3pm.

Solar radiation is very low at night but increases very rapidly at the 6am sunrise, peaking at midday. In the evening, reflected radiation from the ground is higher than the direct radiation levels.

Data for a few river level sites is currently available (Figure 8). The rivers examined in the study appear to have different behaviours, peaking in response to precipitation at different times and in different ways, however water temperature between the river sites appears to be relatively well correlated and is very similar between all the streams.

Focussing in on the Blackwater Creek river level, it can be seen that the creek responds to precipitation events relatively quickly but that it takes about 3 days for the river to reach its peak level. Water levels recede fairly slowly.

The hydro-climate monitoring system is now mostly operational and further results will be available in due course.

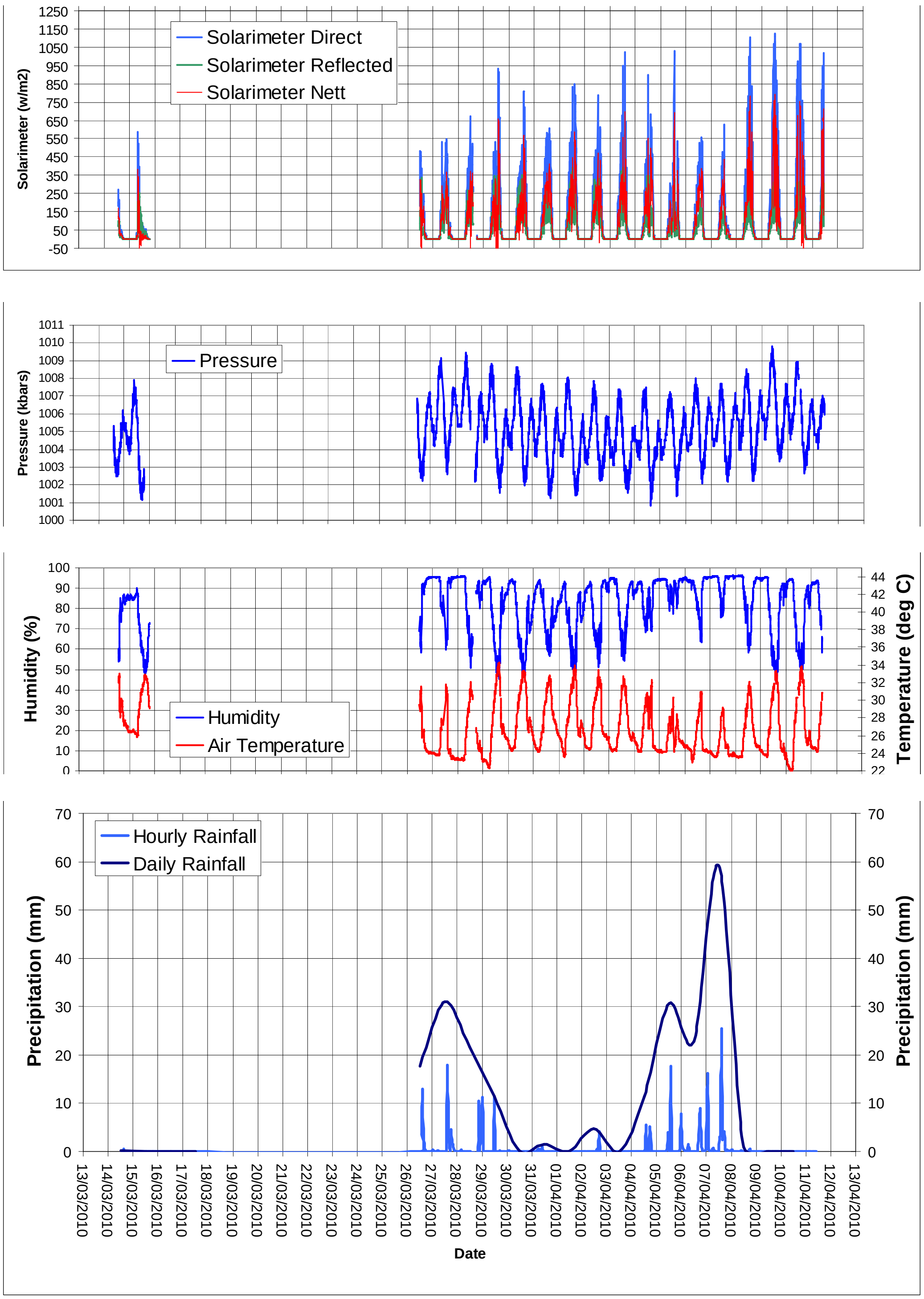
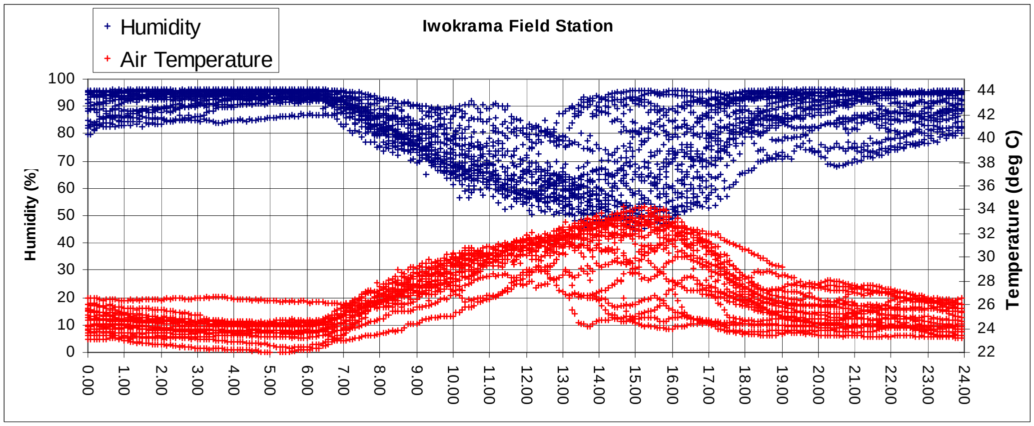


Figure 6 Iwokrama Field Station Automatic Weather Station 1st results for continuous available data between 13/3/10 and 13/4/10.



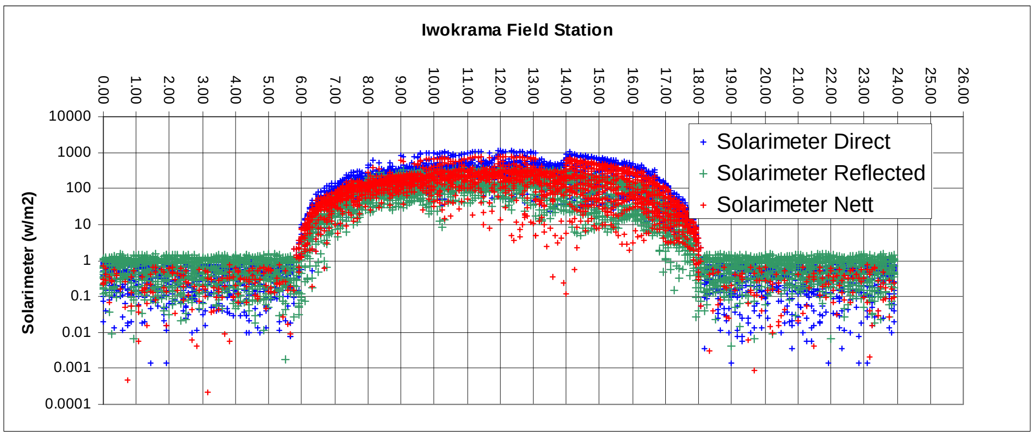
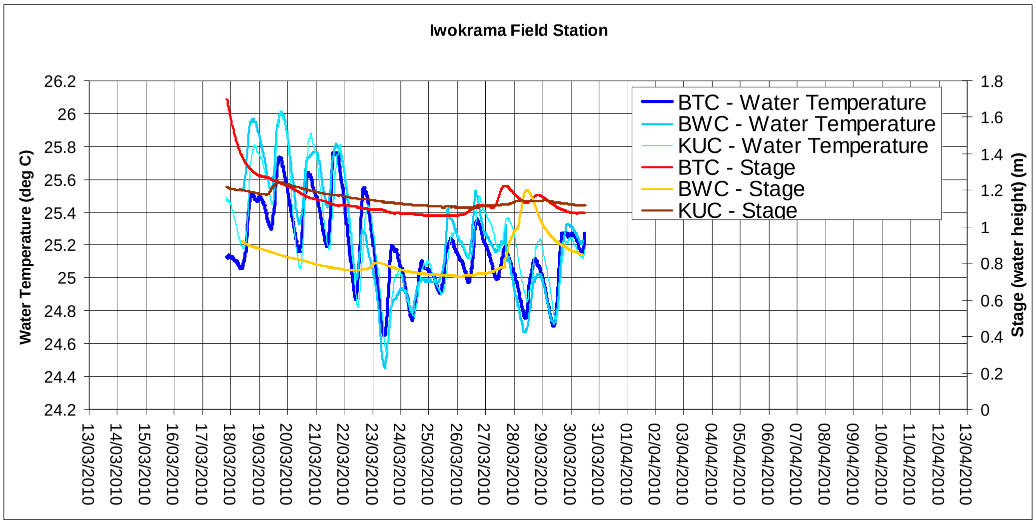


Figure 7 Daily Iwokrama Field Station Automatic Weather Station 1st results for available data between 13/3/10 and 13/4/10.



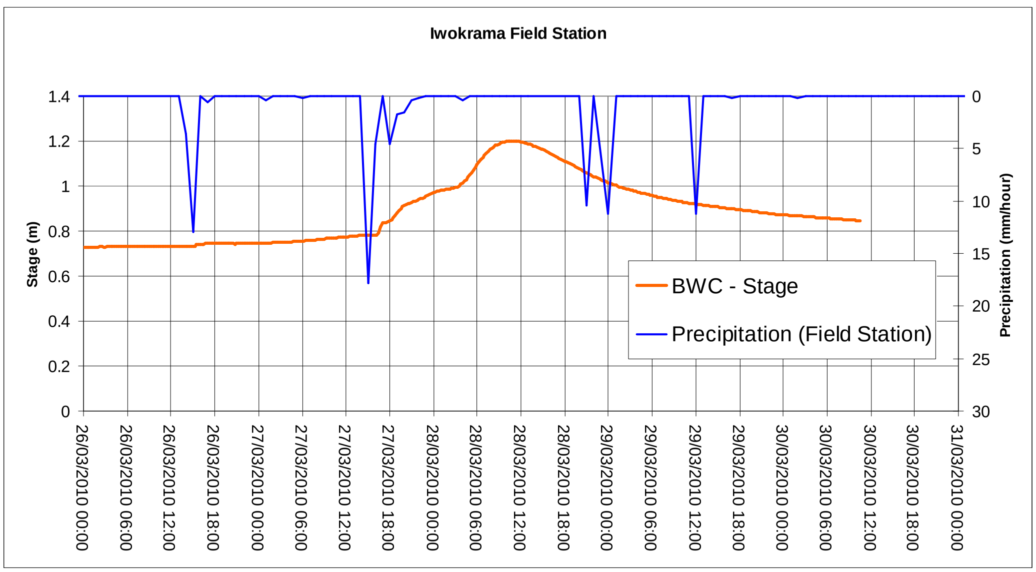
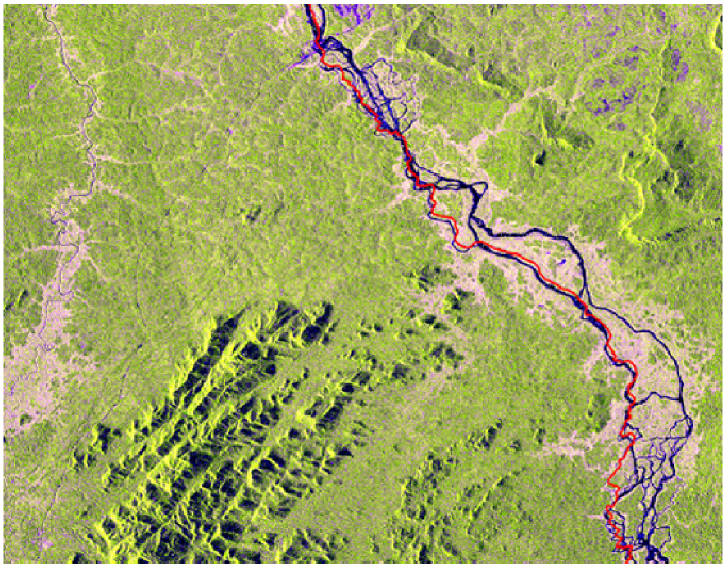


Figure 8 Stream level and stream temperature for Blackwater Creek (BWC), BTC and Kuipari (top) and stream level and hourly precipitation for Blackwater Creek (bottom)

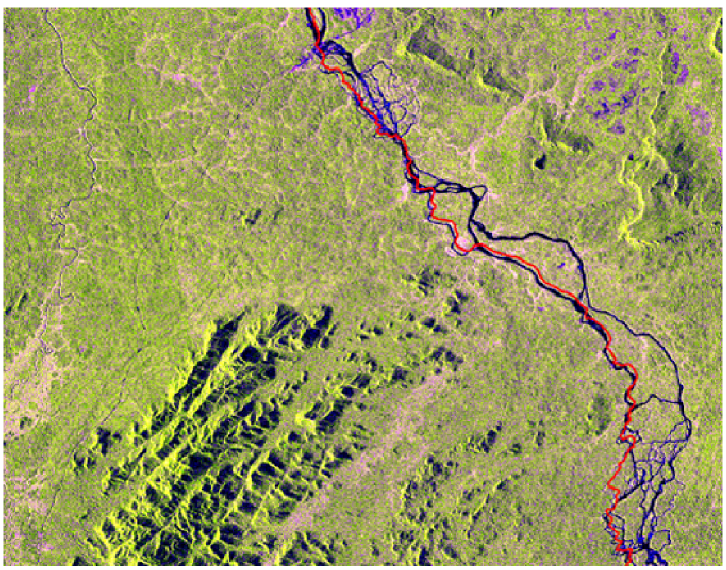
3.2 Water quantity/flood dynamics

The following examples were provided by Sarvision to show that it is possible to measure the extent of flooding even under forest canopy using ALOS PALSAR radar satellite imagery. In the pictures the pink areas (particularly evident along rivers) represent flooded areas under canopy. Data used is ALOS PALSAR imagery at 25m.

Flooded area in July 2008 (Wet Season)



Flooded area in September 2008 (Dry Season)



3.3 Water quality

Background

The quality of water is essential when considering its various uses. It can be defined by a range of parameters, each of which has its own demands and influences on both other parameters and the water quality itself. Water quality can also be affected by natural and anthropogenic influences such as geological, hydrological, climatic, variations in seasonal differences such as runoff, weather conditions and water levels, as well as industrial and faecal discharge. Significant changes to the natural water quality can result in disruption of the ecosystem.

These influences affect water quality in several ways. Intense rains affect the water level and flow and thus increase the dissolved oxygen in the water. Erosion and mineral weathering can concentrate the dissolved material through evpouration and evapo-transpiration. Terrestrial vegetation decomposition in soil affects the organic and nitrogen compounds in water. While the growth, death and decomposition of aquatic vegetation can increase concentrations of nitrogenous and phosphorous nutrient as well as pH, carbonates and dissolved oxygen.

An intense water quality monitoring system should include analysis to access the spatial and/or temporal variations in the selected water body. This should include;

- **water quality** – biological tests, toxicity tests and enzyme measurements
- t**he composition and state of the biological life** – description of aquatic organisms including their occurrence, density, biomass, physiology and diversity
- **the nature of the particulate matter** – chemical analysis of water, particulate matter and aquatic organisms such as planktonic algae
- **the physical description of the water body -** temperature, pH, conductivity, light penetration, particle size of suspended and deposited material

For the purpose of this study only the physical description of the selected water bodies were sampled. It is also important to note that the results of analyses performed on a single water sample are only valid for that particular location and time

Temperature

Temperature is a major parameter to be tested for water quality because of its direct and indirect influence on almost all other parameters and the water body itself. It has a direct inverse relationship with dissolved oxygen and can affect aquatic species if higher or below their tolerance level. It can be influenced by both natural conditions such as adjacent land vegetation and seasonal fluctuations as well as anthropogenic such as the introduction of cooled or heated water.

Dissolved oxygen

This is a relative measure of the amount of saturated gaseous oxygen that is dissolved in the water. It is the most important parameter in aquatic systems since it is an absolute requirement for the metabolism of aerobic organization and can influence inorganic chemical reactions. Equally important is that at an extremely high level dissolved oxygen in water can be severely harmful to aquatic organisms and can cause decompression sickness. Therefore, knowledge of the solubility and dynamics of oxygen distribution is essential to interpreting both biological and chemical processes within water bodies.

Oxygen gets into water by diffusion from the surrounding air, by aeration (rapid movement) and as a waste product of photosynthesis. The amount of dissolved oxygen gas is highly dependent on temperature. The amount of oxygen that can dissolve in water is inversely proportional to the temperature of the water. The warmer the water, the less dissolved oxygen there is. Atmospheric pressure also has an effect on dissolved oxygen.

Turbidity

Turbidity is a measure of the clarity of water. The cloudiness of water is caused be suspended particulate matter. Turbidity is also a key parameter when testing water quality. There are several sizes of particulars suspended in a water body. Heavier particles tend to settle while smaller lighter particles remain suspended and cause water to appear turbid.

Turbidity is caused both natural and anthropogenic activities including growth of phytoplankton, water flow and weather conditions particularly heavy rains as well as construction and mining. It reduces the amount of sunlight that reaches the lower depths of a waterway thus inhibiting the growth of aquatic plants that fish depend.

Electrical Conductivity (EC)

This is the measure of how conductive the water is to electrical current. Electrical conductivity is intrinsically linked to the ion concentration and Total Dissolved Solids (TDS) within a water body. The higher the ion concentration, the higher the EC. The higher the EC, the higher the TDS.

EC is influenced by several factors including geology, size of the water shed, pollutants, evaporation, biological. The dissolved solids in the water dissociate and form ions in the water making it a conductor of electricity. The conductivity of a solution is highly dependent on its concentration of dissolved salts and sometimes of chemicals within the water that are ionized.

It can therefore be deduced the EC of water is an indication of how salt-free, ion-free or impurity-free the water is. Drinking water has a conductivity of 0.0005 – 0.05. Deionized water has very few ions and therefore a low EC.

pH

pH is the measure of the acidity or alkalinity of a solution. It is short for 'potentionmetri hydrogen ion concentration'. pH is measured against the pH scale which ranges from 1 being acidic, 7 being neutral, and 14 being alkaline. While the pH of pure water is 7, in the natural environment this is not the case. For example, many tropical fish can survive comfortably in water with a much lower pH and can range between 6.5 and 8.0. Sudden changes in pH above the tolerance level of fish species can cause stress or even death. pH is influenced be natural and human activities such as rain, which can be below pH 5 and runoff of nitrogen or sulfuric emissions. The acidity of freshwater depends on the calcium carbonate in the soil which helps to neutralize the acidity of the water. As pH approaches 5 and below fish populations begin to decrease

Effects of pH on aquatic life include a decrease in fish populations and increase in plankton and mosses. The most serious chronic effect is the interference with the fish's reproductive cycle. Juvenile fish can also be killed at extreme pH levels.

Methodology

Water quality monitoring is done with the use of a YSI556 multi-probe which reads four parameters; Temperature, Dissolved oxygen, Electrical conductivity and pH. Sampling is done at the beginning of each bird transect (see Section 3.2.5 for location of transect lines). Sampling is done on the shaded side of the boat.

Temperature; Dissolved Oxygen; Electrical Conductivity; pH

- At the start of the bird transect the probe module, is placed into the river, with the instrument and sensor guard on ensuring all the probe sensors are completely covered.
- The probe is moved rapidly through the water without bringing any of the sensors above the water surface.
- When the displayed figures have been stable for three seconds or more the Enter key is pressed and the data recorded

Turbidity

- The Secchi disk is slowly lowered into the river on the shaded side of the boat until it is no longer visible. This depth is recorded.
- Slowly raise the disk until it becomes barely visible. This depth is recorded. The average of these two depths is taken and recorded as the Secchi depth. This may be repeated.

Baseline data

Data presented in this report cover the sample period March – July and November – December 2009. The gap is a result of the unavailability of the battery pack for the YSI 556 multi-probe. It is important to note there were cases of high rainfall in March, June, July and December since this significantly affects the water quality.

Temperature

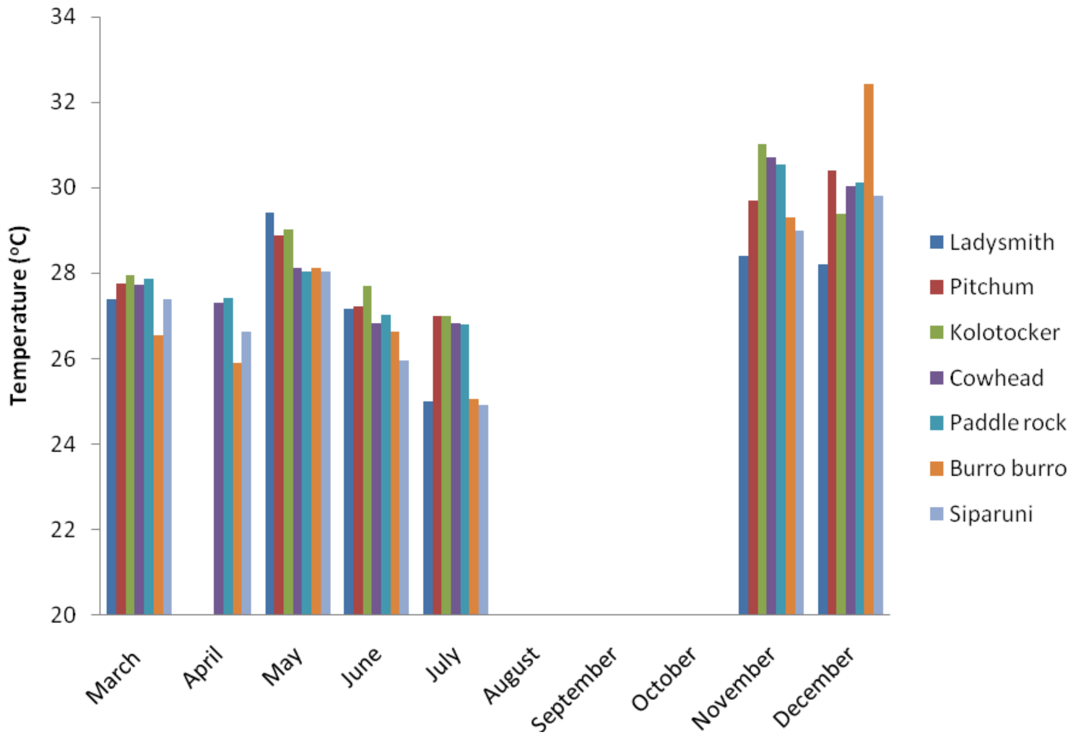


Figure 1. A comparison of the temperature variations for the seven sample sites for the sampling period March through December. Data could not be collected for the period August – October due to instrumental problems

Dissolved Oxygen

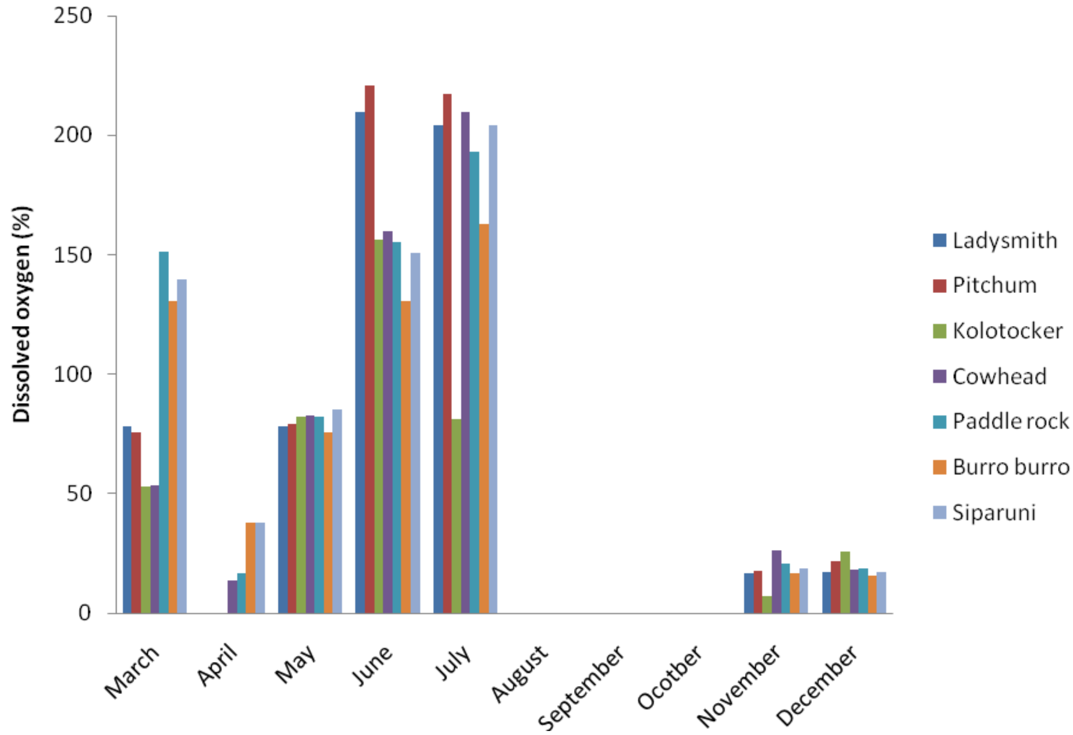


Figure 2. Dissolved oxygen variations for the sample period

Turbidity

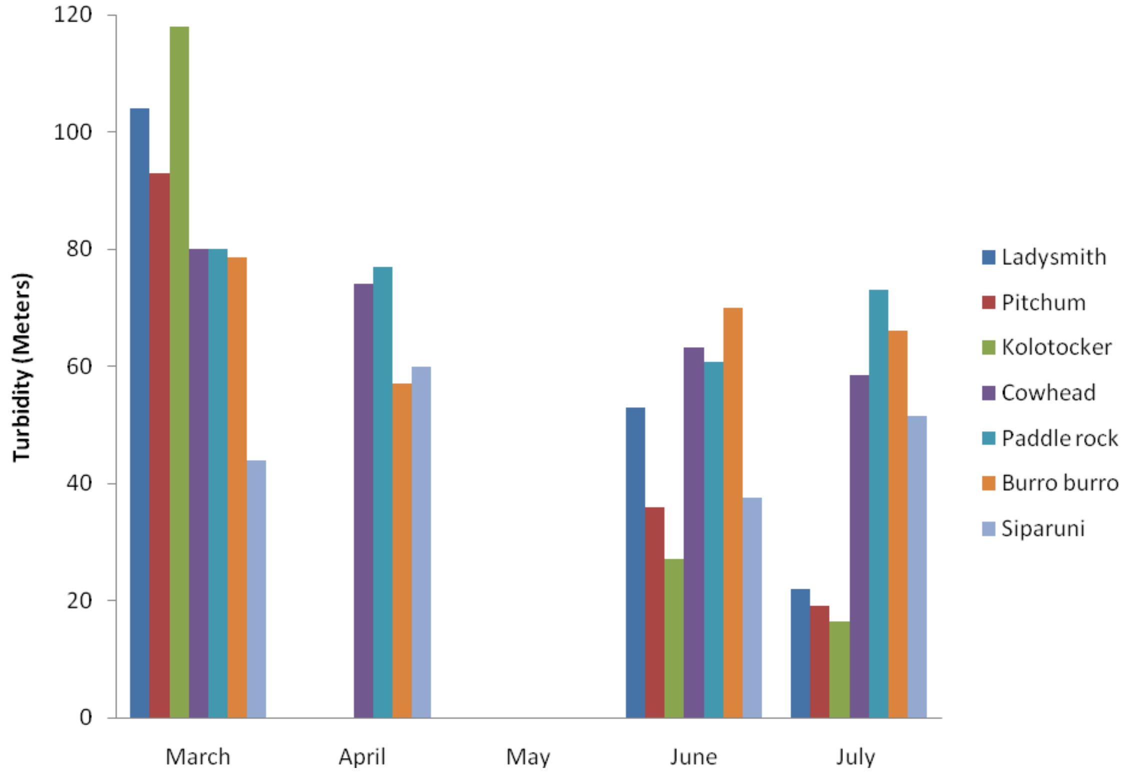


Figure 3. Shows the clarity of the water in meters. Note: The higher the value the clearer the water.

Electrical Conductivity

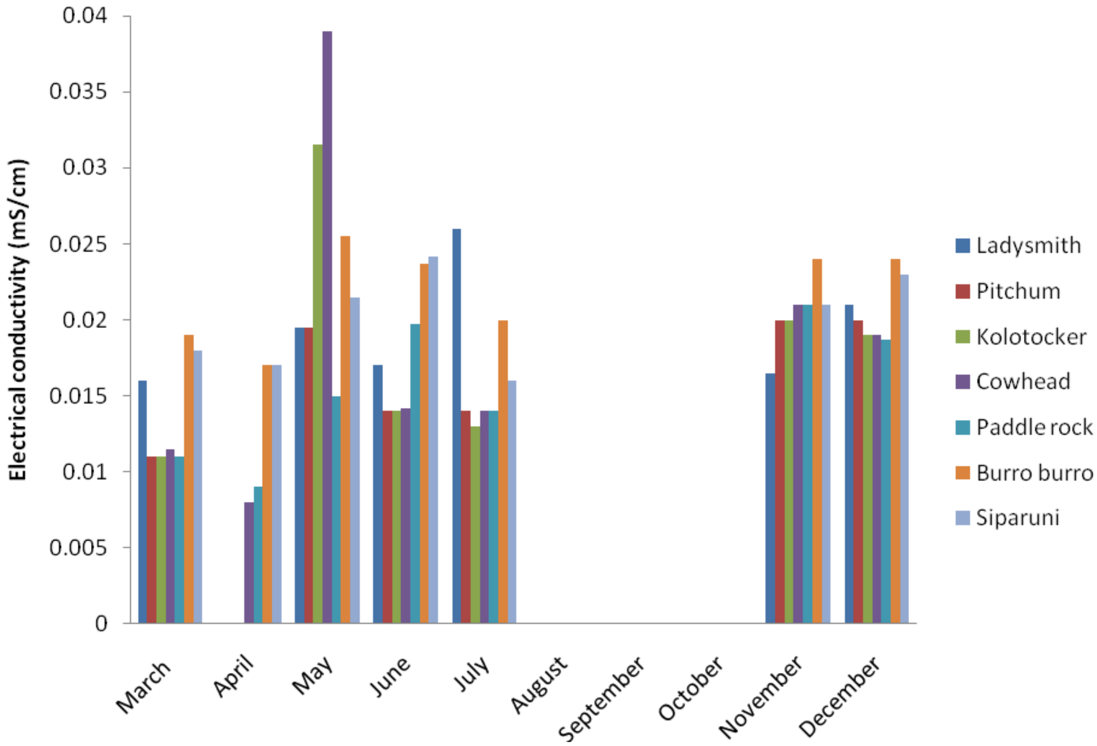


Figure 4. Electrical conductivity for the seven sample sites.

pH

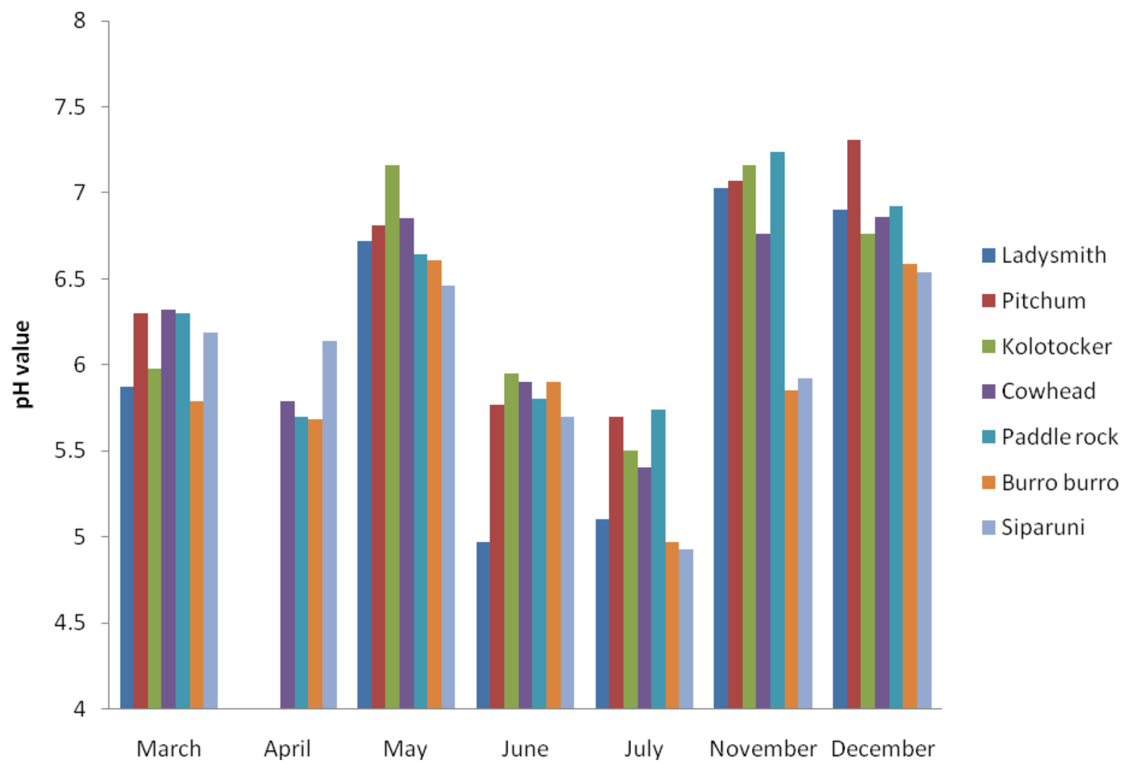


Figure 5. pH variations at the sample sites for the sample period.

Conclusion

From the data gathered during the sampling period some patterns can be seen in all parameters tested except electrical conductivity.

There was an increase in dissolved oxygen from April to July after which it begins to decrease. This is the rainy season period resulting in an increased water level and flow allowing for increased aeration within the waterway. Additionally the inverse relationship between temperature and dissolved oxygen can also be observed during this period.

There is a noticeable difference in turbidity results between sample sites upstream and downstream of IRL. Upstream results fluctuated significantly during the sample period and appear to be highly influenced by the rainy season. Downstream sample sites appear more stable with a notable decrease in the Siparuni River site. The stability in the turbidity level may be attributed to the constant vehicular movement on the river in comparison to upstream where this is limited.

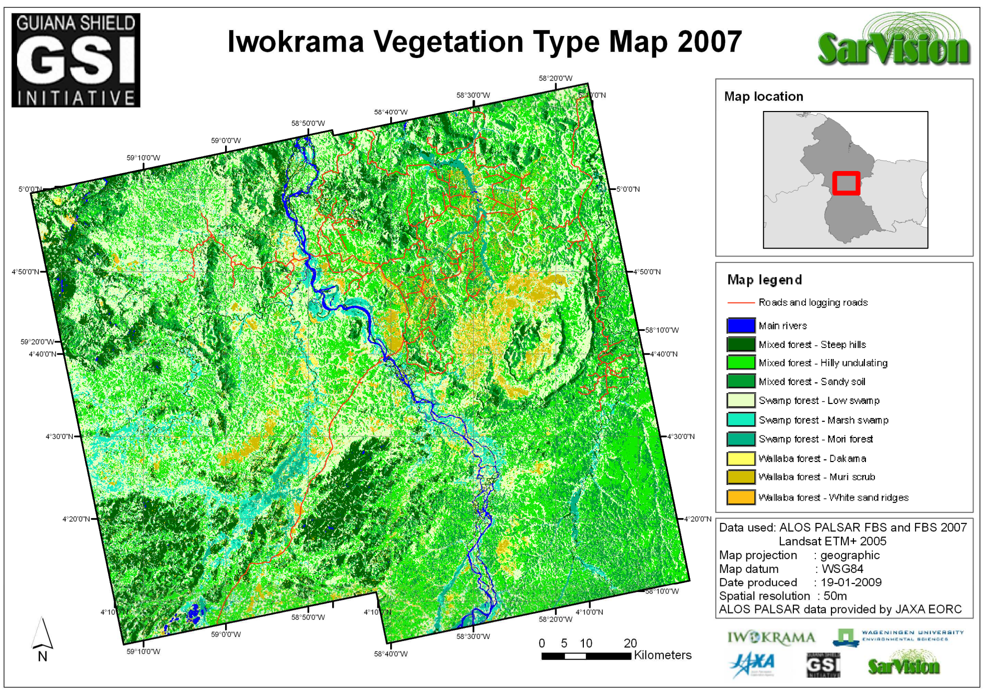
Electrical conductivity is influenced by numerous factors which need to be monitored over an extended period of time before any deductions can be made with regard to the fluctuations observed. pH for all the sites increased in May and November which are the onset of the two rainy seasons which increases the water level and runoff.

A longer sampling period will allow for greater deductions to be made and a distinction between direct and indirect influences.

4. BIODVERSITY

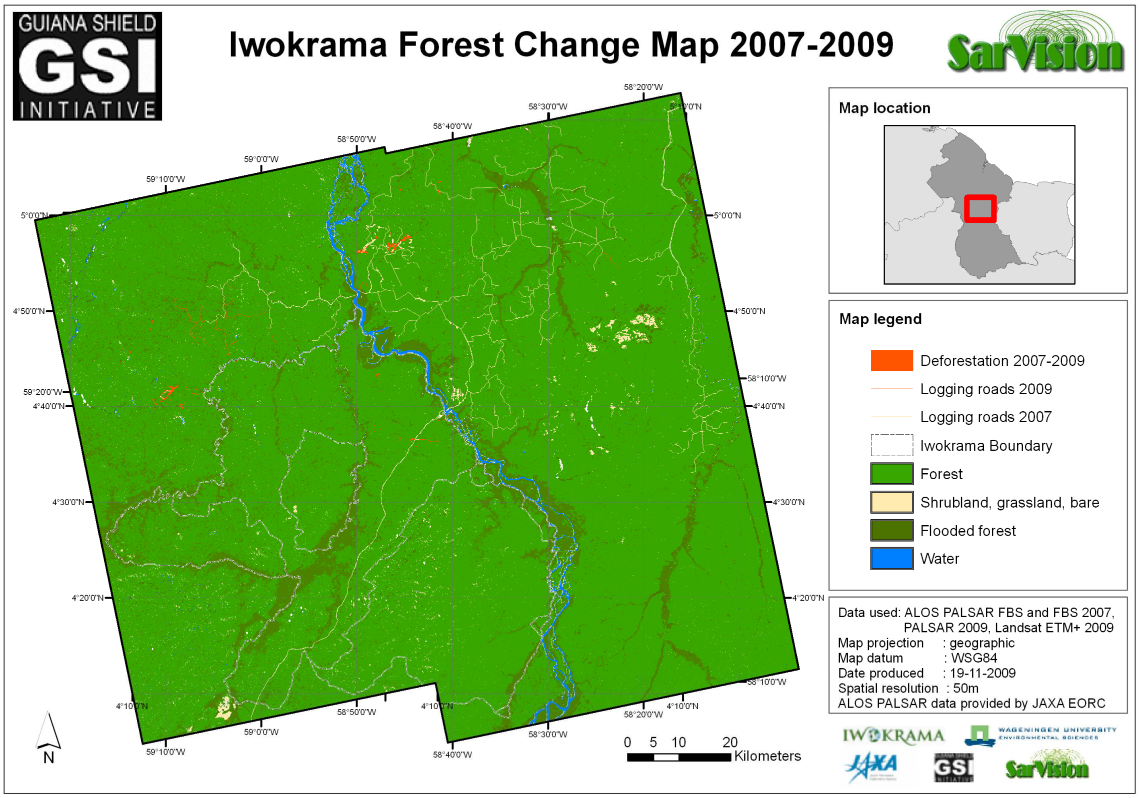
4.1 Ecosystem level

Sarvision map on Vegetation – Needs interpretation (Re: UNDP)



4.2 Forest Change

The Sarvision generated map below gives an indication of deforestation/degradation (areas in red) that occurred within the Iwokrama forest from between 2007 and 2009. No significant changes were detected. Areas that showed up were the new Mill Site for the timber operation and havesting roads. Some areas that showed up were checked by flying over the forest but were noted to be dried out areas of vegetation (due to extreme dry conditions caused by the El Nino).



4.3 Species Level

4.3.1 Permanent Sample Plots

Permanent sample plots (PSP) are permanently demarcated areas of forest, typically of one hectare, which are periodically remeasured. PSP are the base of growth and yield studies (Alder and Synnott, 1992). They allow for gaining knowledge on forest changes under different situations. Forest management, then, can be based on this knowledge and be continuously adapted to new information.

With Iwokrama starting in 2007 the sustainable management of some 108,000 ha of forest for timber production, there was a need of a system of PSP for both sampling and experimental purposes.

The system of PSPs in the Iwokrama Forest will be able to register forest change within existing and regular conditions, such as those found in the unlogged forest and in those areas where regular management plan prescriptions are applied. At the same time, experimental PSPs will explore different management regimes, in this case different harvest intensities, to be applied at field trials at a scale which could also facilitate other monitoring and analyses.

In line with goals of environmental conservation and sustainable use of the forest biodiversity, the PSPs will also attempt to provide information on other important elements related to these goals, such as non-timber forest products, the presence of invasive alien species, and carbon storage in specific carbon pools of the forest.

The establishment of twelve one-hectare PSP was originally planned for the project. They include eight PSP to be established as classical sample plots in the four major forest types of the Net Operable Area (NOA) and four experimental plots. Thirteen PSP were finally established, nine sample plots and four experimental plots.

The GSI project did not support this aspect of the monitoring. Some of the PSPs were remeasured in 2009 and results are pending. Due to the ecology of Guianan forest plant species (general slow growth) , PSPs require long term considerations to have effective results.

4.3.2 Biodiversity surveys

Background

From October 2008 – April 2010, the Iwokrama monitoring team conducted pre-timber harvest Forest Impact Monitoring surveys in six forestry management units.

These surveys form the first half of a study that will investigate the impacts of Iwokrama's forestry operation on the forest's wildlife. Surveys are designed to census population numbers and species diversity of bats, birds, primates, rodents, and other large mammals. Starting in November 2010, these surveys will be replicated at the same sites after logging, for a comparison of species abundance and diversity pre and post timber harvest.

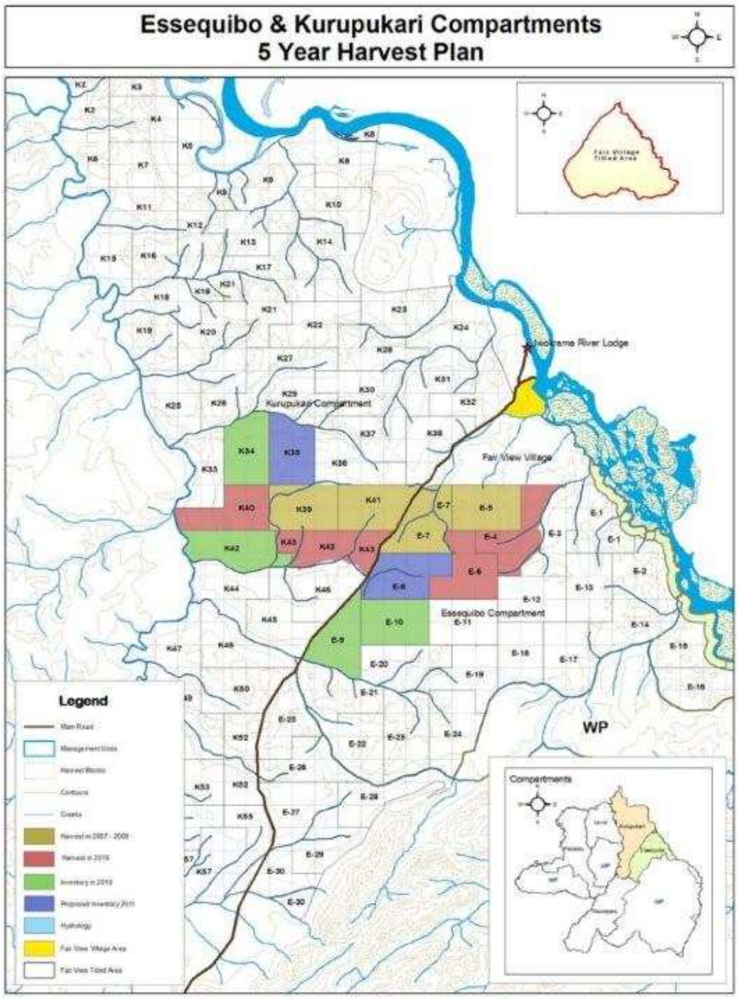


Figure- Harvesting Plan Map showing forest management units to be harvested

Methods

Abundance and diversity of forest vertebrate taxa were sampled at four spatially independent sites within all of the six forestry management units (totalling 24 sites) due to be harvested during the survey period. Straight-line transects were located along the longest line possible within the management unit. All management units were located within areas classified as Mixed Greenheart, Kakaralli (MGK) which is dominated by *Chorocadium rodiei* (Greenheart*), Eperua falcate* (Soft Wallaba*), Dicorynia guianensis (*Waramadan*).* On a smaller scale, transects sometimes passed through wetter swampy areas, but in general all sampling sites were in MGK forest. Responses of forest vertebrates are quantified through a strict pair-wise survey design where each site is surveyed before and after logging. The spatial arrangement of sites, transects and mist-net locations are displayed in Fig. 1. Total survey effort is summarised in Table 1.

Table . Management unit details and sampling effort.

Management Unit	Dates surveyed	Forest type[1]	Bat 12m net hours	Bird 12m net hours	Point counts	Mammal transect km
K41	Nov-08	MGK	1728	2511	120[2]	56
E6	Feb-09	MGK	1665	2354	66	24
K39	Mar-09	MGK	1629	2646	63	38
K40	Nov-09	MGK	1683	2583	56	37
E4	Nov/Dec 09	MGK	1683	2484	63	35.4
K43	Jan-10	MGK	1719	2529	48	32.7
Total			**10107**	**15106**	**416**	**223.1**

[1]MGK - Mixed Greenheart, Kakaralli. Dominated by *Chorocadium rodiei, Epurua falcata, Dicorynia guianensis*

[2]Point count sampling effort was changed after the first management unit, as the aimed 120 point counts was both too labour intensive and unnecessary.

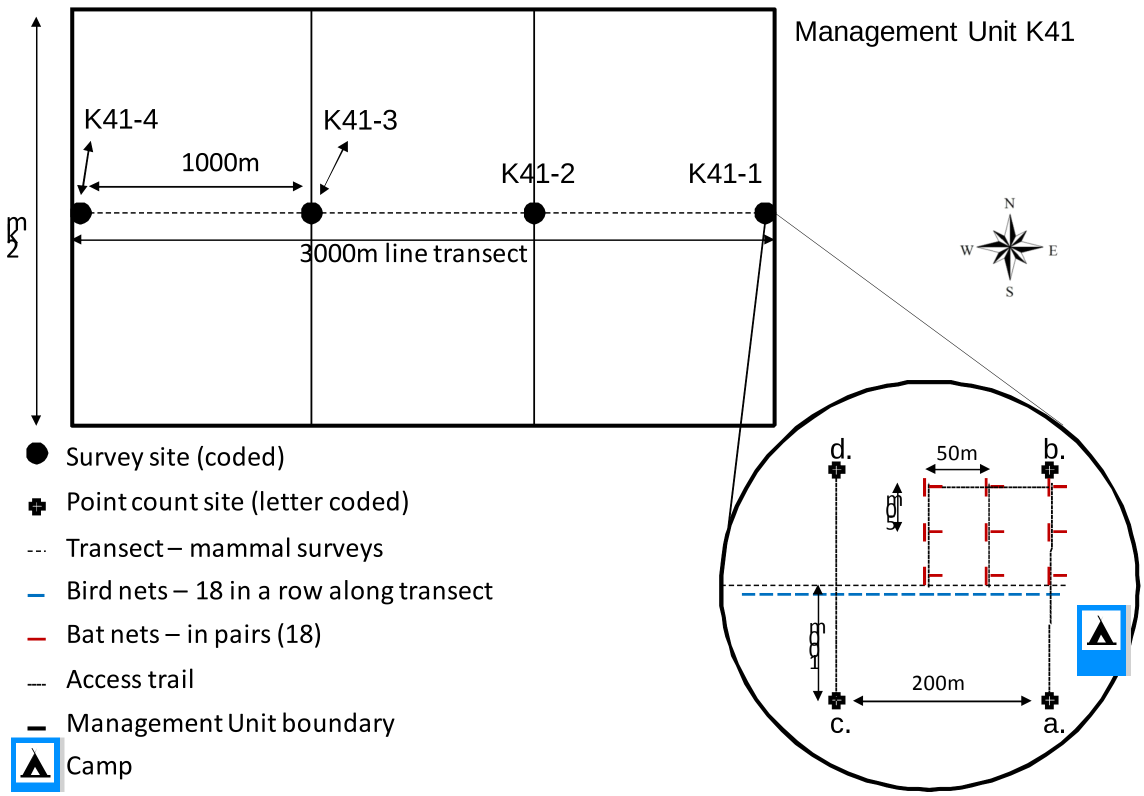


Fig. 1. Spatial arrangement of sampling sites within management units. Each management unit has a 3km transect (used for sampling large mammals) through the centre, with four sites along the transect 1km apart. These sites are used for mist netting bats and birds, and for bird point counts.

The following summarises sampling methods and effort for each taxa at each site.

Bats

- 18 (12 metre) mist nets placed at ground level (0-2.5m) in pairs at each of the 9 positions in the grid format, shown in Figure 1.
- Opened at 18:00 and closed at 00:00.
- Surveyed for 4 nights per site = 432 mist net hours per site

Birds

Mist nets

- 18 (12 metre) mist nets placed directly along the transect line, shown in Figure 1.
- Opened at 06:00 and closed at 18:00.
- Surveyed for 3 days per site = 621 mist net hours per site

Point Counts

- 10 minute point counts.

- 4 locations per site, 200m spaced shown in Figure 1.
- Total 16 point counts per site = 160 minutes of counts per site.
- Upon detection of target species the radial distance is measured, as well as the group size and any available demographics.
- Each surveyed on 4 mornings.
- Between the hours of 06:00 – 09:00.

Non-volant mammals

- Line transects surveyed every morning.
- Between the hours of 06:00 – 09:00.
- Observers slowly walk the transect observing for target species. Upon detection of target species the perpendicular distance is measured, as well as the group size and any available demographics.
- Total number of approximately 40km completed per Management Unit can vary. Minimum 20km.

Baseline abundance data

Terrestrial mammals

Table 2. Pooled density estimates of mammals across six management units, pre-timber harvest. Only species with sufficient detection numbers to generate density estimates are included.

Group & *Species*	Common name	N	Density - ind/km^2 (95% CI)
Primates*			
Ateles paniscus	Black Spider Monkey	28	0.9 (0.6-1.4)
Alouatta macconnelli	Red Howler Monkey	35	0.9 (0.6-1.3)
Rodents			
Dasyprocta leporina	Red-rumped Agouti	187	14.8 (12.9-17.1)

The above densities are calculated using distance sampling analysis from a total survey effort of 223km.

*The primate density estimates presented here are much lower than have previously been reported for these areas. Encounter rates have not significantly changed from previous estimates, and from further data investigation it seems that these low estimates are a product of random phenomena whereby these primate groups were rarely detected close to the transect line in these surveys. Therefore the data used in this distance sampling analysis result in a skewed detection 'shoulder', whereby the majority of detections are far from the line. This violates one of the primary assumptions of distance sampling, and therefore these data should be interpreted with caution. For post forestry analysis, these data will be explored more thoroughly, and will also be analysed at the Management Unit level.

Bats

Table 3. Pooled relative abundance of Phyllostomidae bats in six management units comprising four sites in each (total 24 sites) in the Iwokrama Forest pre-logging.

Sub-Family *Species*	N	Feeding guild[1]	Catch per 100 12m net hrs	% of sample
Caroliinae				
Rhinophylla pumilio	96	F	0.950	10.87
Carollia perspicillata	29	F	0.287	3.28
Glossophaginae				
Lonchophylla thomasi	3	N	0.030	0.34
Lionycteris spurrelli	6	N	0.059	0.68
Glossophaga soricina	12	N	0.119	1.36
Choeroniscus minor	20	N	0.198	2.27
Phyllostominae				
Glyphonycteris daviesi	14	G	0.139	1.59
Glyphonycteris sylvestris	1	G	0.010	0.11
Micronycteris brosetti	2	G	0.020	0.23
Micronycteris megalotis	2	G	0.020	0.23
Chrotopterus auritus	17	C	0.168	1.93
Lophostoma brasiliense	7	?	0.069	0.79
Lophostoma schulzi	2	?	0.020	0.23
Lophostoma silvicolum	26	?	0.257	2.94
Micronycteris hirsute	4	G	0.040	0.45

Trachops cirrhosus	14	C	0.139	1.59
Micronycteris microtis	7	G	0.069	0.79
Trinycteris nicefori	2	G	0.020	0.23
Tonatia silvicola	3	?	0.030	0.34
Tonatia saurophila	20	G	0.198	2.27
Phyllostomus hastatus	4	O	0.040	0.45
Phyllostomus elongatus	32	O	0.317	3.62
Phylloderma stenops	6	O	0.059	0.68
Mimon crenulatum	21	G	0.208	2.38
Micronycteris minuta	1	G	0.010	0.11
Phyllostomus discolor	3	C	0.030	0.34
Stenodermatinae				
Mesophylla macconnelli	7	F	0.069	0.79
Artibeus gnomus	25	F	0.247	2.83
Artibeus lituratus	239	F	2.365	27.07
Artibeus obscurus	89	F	0.881	10.08
Artibeus planirostris	115	F	1.138	13.02
Vampyressa bidens	12	F	0.119	1.36
Chiroderma trinitatum	6	F	0.059	0.68
Chiroderma villosum	6	F	0.059	0.68
Vampyressa Brocki	1	F	0.010	0.11
Artibeus concolor	7	F	0.069	0.79
Artibeus glaucus	1	F	0.010	0.11
Vampyressa pusilla	1	F	0.010	0.11
Sturnira tildae	5	F	0.049	0.57
Uroderma bilobatum	6	F	0.059	0.68
Vespertilioninae				

Desmodus rotundus	9	S	0.089	1.02
Total	883			

The above measurements of relative abundance are calculated from 10,107, 12 metre net hours.

[1]Feeding Guilds: C = Carnivore; F = Frugivore; N = Nectarivore; O = Omnivore; S = Sanguinivore

Birds

Table 4. Density of canopy and terrestrial birds in six management units comprising four sites in each (total 24 spatially independent sites) in the Iwokrama Forest pre-logging. Additionally, each site is broken into four point count locations so these data total 26 sampling locations. Only species with sufficient numbers of detections are included.

Family & *Species*	N	Density - ind/km^2 (95% CI)
Guans		
Black Currasow	32	3.75 (1.2-12.0)
Greenlets		
Buff-cheeked greenlet	92	4.3 (0.8-21.7)
Woodpeckers		
Waved woodpecker	74	1.3 (0.8-2.3)
Oropendulas		
Green & crested oropendula*	43	0.6 (0.2-1.7)
Parrots, macaws, parakeets		
Macaws (Red & green, and scarlet)*	28	0.42 (0.2-0.9)
Black-headed parrot	40	1.6 (0.6-2.8)
Blue-cheeked amazon	83	4.0 (1.5-10.5)
Mealy parrot	85	2.9 (1.2-7.3)

Dusky parrot	53	3.3 (1.2-9.2)
Golden-winged parakeet	36	3.3 (2.0-5.6)
Pigeons		
Plumbeous pigeon	81	0.9 (0.5-1.6)
Pihas		
Screaming piha	182	7.7 (4.6-13.1)
Tinamous		
Variegated and great tinamou*	45	0.4 (0.2-0.8)
Toucans		
Channel-billed toucan	82	2.1 (1.4-3.0)
Red-billed toucan	55	0.6 (0.4-1.0)
Trogons		
Black-tailed trogon	46	1.6 (0.5-4.9)
White-tailed trogon	42	2.2 (0.8-6.4)

Total effort = 416 point counts, totalling 4160 minutes. Only species with sufficient data for distance sampling analysis are reported here. *Some species are grouped based on similar ecology – to enable sufficient sample size for density estimation.

Table 5. Pooled relative abundance of birds sampled by mist nets in six management units comprising four sites in each (total 24 sites) in the Iwokrama Forest pre-timber harvest.

Family Species	N	Catch per 100 12m net hrs	% of sample
Antbird			
White-plumed Antbird	214	1.417	11.08
Scale-backed Antbird	114	0.755	5.90
Rufous-throated Antbird	56	0.371	2.90
Dusky Antbird	23	0.152	1.19

Wing-banded Antbird	14	0.093	0.72
Dusky-throated Antbird	7	0.046	0.36
Spot-winged Antbird	5	0.033	0.26
Black-chinned Antbird	4	0.026	0.21
Warbling Antbird	2	0.013	0.10
White-crowned antbird	2	0.013	0.10
Ferruginous-backed antbird	1	0.007	0.05
Antpipit			
Ringed Antpipit	3	0.020	0.16
Antpitta			
Spotted Antpitta	5	0.033	0.26
Antshrike			
Dusky-throated Antshrike	97	0.642	5.02
Mouse-coloured Antshrike	15	0.099	0.78
Cinereous Antshrike	10	0.066	0.52
Black-throated Antshrike	5	0.033	0.26
Eastern Slaty antshrike	1	0.007	0.05
Fasciated antshrike	1	0.007	0.05
Streak-backed antshrike	1	0.007	0.05
Antthrush			
Black-faced Antthrush	17	0.113	0.88
Rufous-capped Antthrush	12	0.079	0.62
Antwren			
Long-winged Antwren	86	0.569	4.45
Rufous-bellied Antwren	40	0.265	2.07
Brown-bellied Antwren	20	0.132	1.04
Grey Antwren	13	0.086	0.67

White-flanked Antwren	8	0.053	0.41
Slaty Antwren	1	0.007	0.05
Plain-winged antwren	1	0.007	0.05
Barbthroat			
White-tailed barbthroat	7	0.046	0.36
Cotinga			
Guianan Red cotinga	3	0.020	0.16
Dove			
Ruddy quail dove	4	0.026	0.21
Grey-fronted Dove	1	0.007	0.05
Emerald			
Blue-tailed Emerald	1	0.007	0.05
Glittering-throated Emerald	1	0.007	0.05
Falcon			
Lined Forest Falcon	5	0.033	0.26
Flatbill			
Olivaceous flatbill	2	0.013	0.10
Rufous-tailed Flatbill	1	0.007	0.05
Flycatcher			
McConnell's Flycatcher	150	0.993	7.76
Ochre-bellied Flycatcher	22	0.146	1.14
Whiskered Flycatcher	15	0.099	0.78
Amazonian Royal Flycatcher	7	0.046	0.36
Dusky-capped Flycatcher	2	0.013	0.10
Yellow-olive flycatcher	2	0.013	0.10
Ruddy tailed flycatcher	1	0.007	0.05
Foliage-gleaner			

Ruddy Foliage-gleaner	7	0.046	0.36
Buff-throated foliage-gleaner	5	0.033	0.26
White-throated foliage-gleaner	2	0.013	0.10
Rufous-tailed foliage-gleaner	1	0.007	0.05
Greenlet			
Buff-cheeked greenlet	9	0.060	0.47
Tawny-crowned greenlet	4	0.026	0.21
Grosbeak			
Red and black grosbeak	4	0.026	0.21
Yellow-green grosbeak	1	0.007	0.05
Hawk			
Black-faced Hawk	1	0.007	0.05
Hermit			
Eastern Long-tailed Hermit	12	0.079	0.62
Stripe-throated Hermit	3	0.020	0.16
Sooty-capped hermit	1	0.007	0.05
Rufous-Breasted Hermit	1	0.007	0.05
Grey-chinned Hermit	1	0.007	0.05
Reddish Hermit	1	0.007	0.05
Honeycreeper			
Green Honeycreeper	1	0.007	0.05
Purple Honeycreeper	1	0.007	0.05
Jacamar			
Yellow-billed Jacamar	2	0.013	0.10
Jacobin			
White-necked Jacobin	1	0.007	0.05
Kingfisher			

American Pygmy Kingfisher	4	0.026	0.21
Green-and-rufous Kingfisher	2	0.013	0.10
Manakin			
White-crowned Manakin	282	1.867	14.60
White-throated Manakin	26	0.172	1.35
Golden-headed Manakin	13	0.086	0.67
White-Capped Manakin	2	0.013	0.10
Orange-crowned manakin	1	0.007	0.05
Tiny tyrant-manakin	1	0.007	0.05
Yellow-throated manakin	1	0.007	0.05
Motmot			
Blue-crowned Motmot	3	0.020	0.16
Mourner			
Cinereous Mourner	1	0.007	0.05
Piha			
Screaming Piha	2	0.013	0.10
Puffbird			
Collared Puffbird	7	0.046	0.36
Pied puffbird	1	0.007	0.05
Sabrewing			
Grey-breasted Sabrewing	19	0.126	0.98
Saphire			
Blue-chinned Saphire	1	0.007	0.05
Schiffornis			
Thrush-like Schiffornis	30	0.199	1.55
Spadebill			
Cinamon-crested Spadebill	40	0.265	2.07

White-crested Spadebill	13	0.086	0.67
Golden-crowned spadebill	2	0.013	0.10
Yellow-crowned spadebill	1	0.007	0.05
Tanager			
Fulvous-crested Tanager	28	0.185	1.45
Yellow-backed tanager	2	0.013	0.10
Flame-crested tanager	1	0.007	0.05
Thrush			
White-necked Thrush	16	0.106	0.83
Tinamou			
Variegated Tinamou	1	0.007	0.05
Topaz			
Ruby topaz	1	0.007	0.05
Trogon			
Black-throated trogon	2	0.013	0.10
Black-tailed trogon	1	0.007	0.05
Tyrant-Manakin			
Saffron-crested Tyrant-Manakin	10	0.066	0.52
Warbler			
River Warbler	3	0.020	0.16
Woodcreeper			
Wedge-billed Woodcreeper	146	0.967	7.56
White-chinned Woodcreeper	54	0.357	2.80
Plain brown Woodcreeper	28	0.185	1.45
Buff-throated Woodcreeper	29	0.192	1.50
Long-tailed Woodcreeper	14	0.093	0.72
Chestnut-rumped Woodcreeper	12	0.079	0.62

White-throated woodcreeper	6	0.040	0.31
Strong-billed Woodcreeper	5	0.033	0.26
Straight-billed woodcreeper	1	0.007	0.05
Striped woodcreeper	1	0.007	0.05
Lineated woodcreeper	1	0.007	0.05
Woodnymph			
Fork-tailed Woodnymph	12	0.079	0.62
Woodpecker			
Chestnut Woodpecker	5	0.033	0.26
Wren			
Musician Wren	21	0.139	1.09
White-breasted wood wren	1	0.007	0.05
Xenops			
Plain Xenops	18	0.119	0.93
Total	1932		

The above measurements of relative abundance are calculated from 15,106 12 metre net hours.

4.3.3 Road wildlife

Background

Seventy-two kilometres of the Linden – Lethem road passes through the Iwokrama reserve. This is important for wildlife that use the road as a crossing or for drying after a rain.

However, the level of road traffic has been steadily increasing and is expected to continue with the opening of the Takatu Bridge that links Guyana and Brazil. This poses a significant threat to wildlife as an increase in road traffic means an increased exposure of wildlife to both legal and illegal activities such as hunting, collecting, trapping and accidental collisions.

In addition to this, even narrow breaks of less than 100m can represent significant barriers to the movement of animals. The width of the road within the Iwokrama reserve varies between 20m and 100m thus stressing the importance of monitoring of wildlife along the road corridor.

Methods

Wildlife monitoring is done in three main forms including a general patrol, bird transect and burrow pit monitoring. This allows for a wider variety of species to be captured as well as the various environments in which they can be found but in a systematic format.

General patrols capture species that are predominantly found on the road [see Table *&^%]. The patrol vehicle travels at a consistent speed and observations of the targeted species are recorded. Bird transects have been identified with at least on in each of the four major forest types within the Reserve which include Mixed Greenheart, Mora, Muri Scrub and Manicole. Species like the Jaguar and Tapir are more elusive than the Grey-winged Trumpeter and Red-rumped Agouti and are not as frequently seen on the road. They are more likely to be found in used laterite pits known as burrow pits where evidence of their presence can be observed.

Road patrol wildlife observations

- Vehicle travels at a consistent speed not exceeding 60 km.
- Target species are observed (Table 1).
- Upon detection of target species their location, group size and any demographics are noted.

Table 1. Road monitoring target species for all road patrol types.

Taxa & Species	*Scientific name*	IUCN category
Birds		
Grey-winged trumpeter	*Psophia crepitans*	Least concern
Black Currosow (Powis)	*Crax alector*	Least concern
Mammals		
Jaguar	*Panthera onca*	Near Threatened
Puma	*Puma concolor*	Least concern
Red-rumped Agouti	*Dasyprocta leporina*	Least concern
Tapir	*Tapirus terrestris*	Vulnerable
Red-brocket deer	*Mazama americana*	Data deficient
Grey-brocket deer	*Mazama gouazoubira*	Least concern

Giant Anteater	*Myrmecophaga tridactyla*	Near Threatened
Reptiles		
Yellow-footed tortoise	*Geochelone denticulata*	Vulnerable
Anaconda	*Eunectes murinus*	Not evaluated

Bird transects

- There are six pre-defined transects with at least one in each forest type along the road corridor (Table 2.)
- Each 500m transect is walked slowly and quietly while carefully observing all birds that are seen
- All species are target for the bird transect

Table 2. Locations of bird transects along the road corridor.

Location	UTM	Time start	Notes
TGI hill start	X 308213, Y 510350	0730-0800	Before TGI crossing
TGI hill end	X 307979, Y 509902		
8 Mile start	X 306295, Y 507026	0800-0830	8 Mile bridge
8 Mile end	X 306017, Y 506610		
Moco Moco start	X 300419, Y 491440	0930-1030	
Moco Moco end	X 300231, Y 490966		
Muri Scrub start	X 295044, Y 482208	1100-1130	
Muri Scrub end	X 294984, Y 481690		
Mauishparu start	X 285688, Y 469651	1200-1300	
Mauishparu end	X 285179, Y 469651		
Corkwood start	X 277970, Y 461087	1300-1400	
Corkwood end	X 277725, Y 460641		

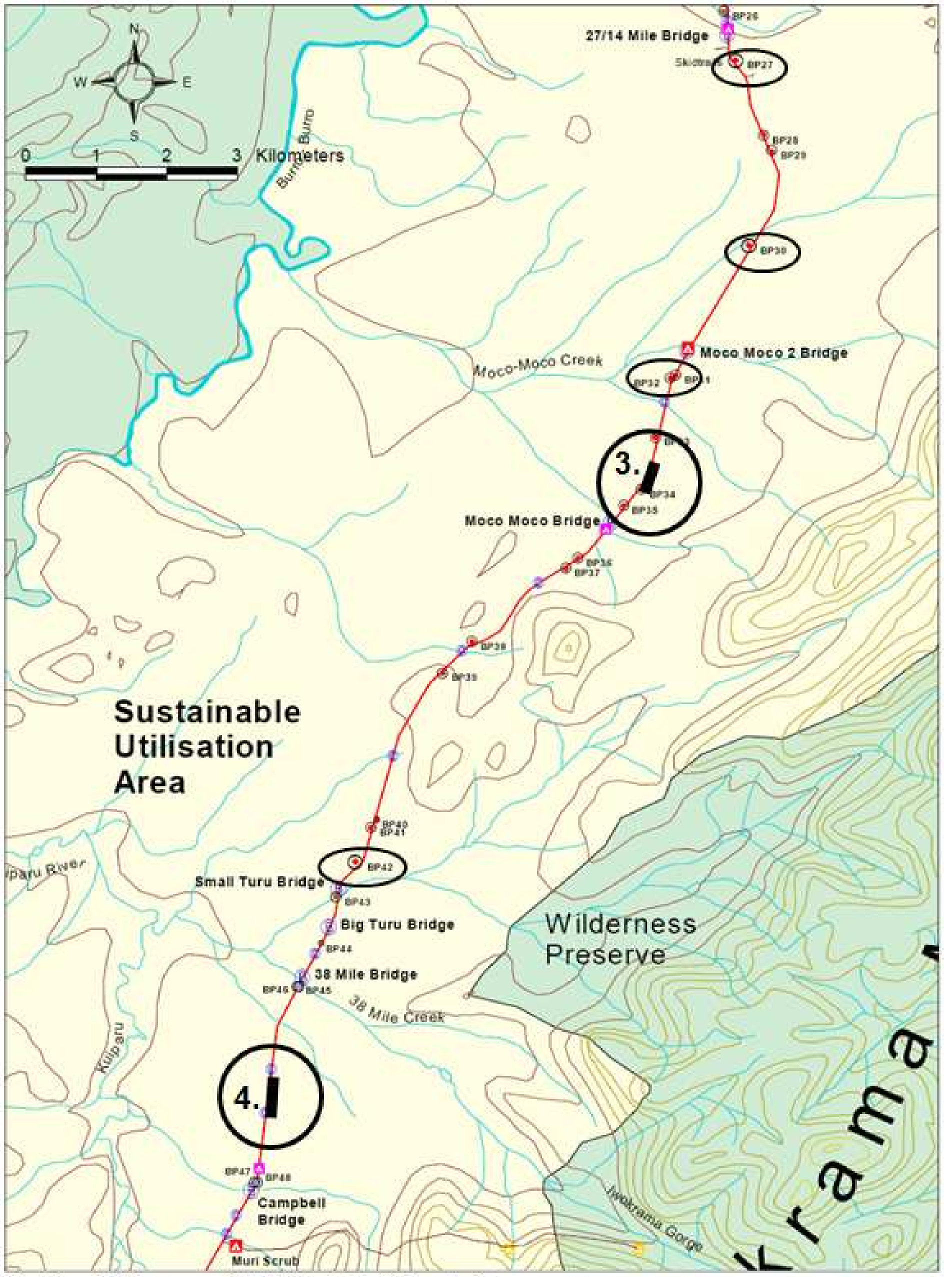
Burrow pits

- Seven burrow pits with size greater than 1 hectare are walked (Table 3).

- The presence of Jaguar and Tapir are observed through the presence of prints and scat.
- Target species utilising wet areas within the pit such as the Anaconda and Tapir are also observed.

Table 3. Locations of burrow pits along the road corridor.

Location	UTM	Time start	Notes
Burrow pit #27	X 301606, Y 497606	Any	
Burrow pit #30	X 301792, Y 494743	Any	
Burrow pit #32	X 300670, Y 492660	Any	
Burrow pit #42	X 296214, Y 485203	Any	
Borrow pit #58	X 292703, Y 474547	Any	Anaconda
Borrow pit #67	X 288420, Y 470876	Any	Anaconda
Borrow pit #73	X 287184, Y 470009	Any	



Section 2: Borrow pit # 26 to Muri Scrub Camp

Bird transect 3: 'Moco Moco' -	Start: X 300419 , Y 491440
	End: X 300231, Y 490966
Bird transect 4: 'Muri Scrub' -	Start: X 295044, Y 482208
	End: X 294984, Y 481690
Borrow pit # 27:	X 301606, Y 497606
Borrow pit # 30:	X 301792, Y 494743
Borrow pit # 32:	X 300670, Y 492660
Borrow pit # 42	X 296214, Y 485203

Figure 1. Showing a portion of the road through the reserve with two bird transects and four burrow pits

Baseline data

The following data is given for the year 2009. The yearly sighting rate is calculated for observations made on general road patrols as follows;

$$Sighting\ rate = \frac{Number\ seen}{Distance\ travelled\ (km)}$$

Comparison are made between traffic and bird transect and burrow pit observations.

Road patrol wildlife observations

Table 4. Road monitoring target species for all road patrol types.

Taxa & Species	*Scientific name*	N	Yearly Sighting rate
Birds			
Grey-winged trumpeter	*Psophia crepitans*	134	0.0341
Black Currosow (Powis)	*Crax alector*	94	0.0279
Mammals			
Jaguar	*Panthera onca*	4	0.0016
Puma	*Puma concolor*	0	0
Red-rumped Agouti	*Dasyprocta leporina*	47	0.0110
Tapir	*Tapirus terrestris*	1	0.0003
Red-brocket deer	*Mazama americana*	0	0
Grey-brocket deer	*Mazama gouazoubira*	1	0.0003
Giant Anteater	*Myrmecophaga tridactyla*	1	0.0002
Reptiles			

Yellow-footed tortoise	*Geochelone denticulata*	0	0
Anaconda	*Eunectes murinus*	2	0.0012

3,384 km total distance travelled on patrols

Bird transects

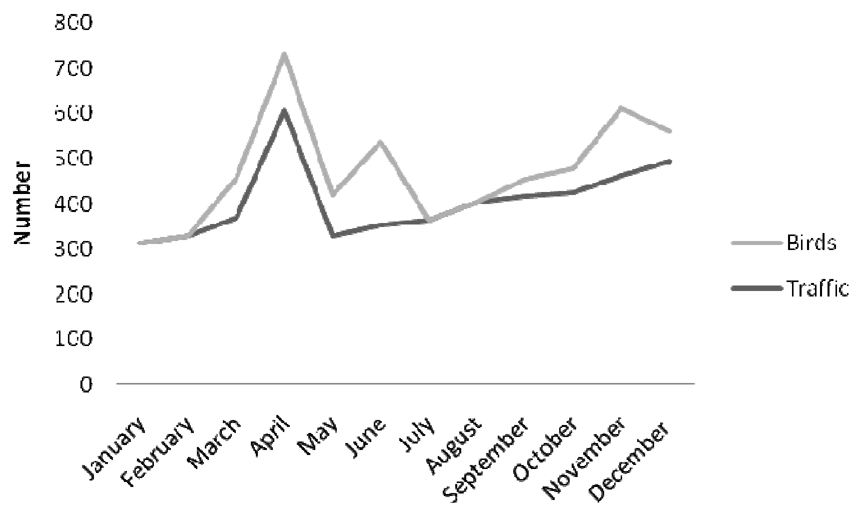


Figure 2. A comparison between the number of vehicles passing through the Iwokrama Forest entering from the Northern boundary and the number of birds observed for 2009

Burrow pits

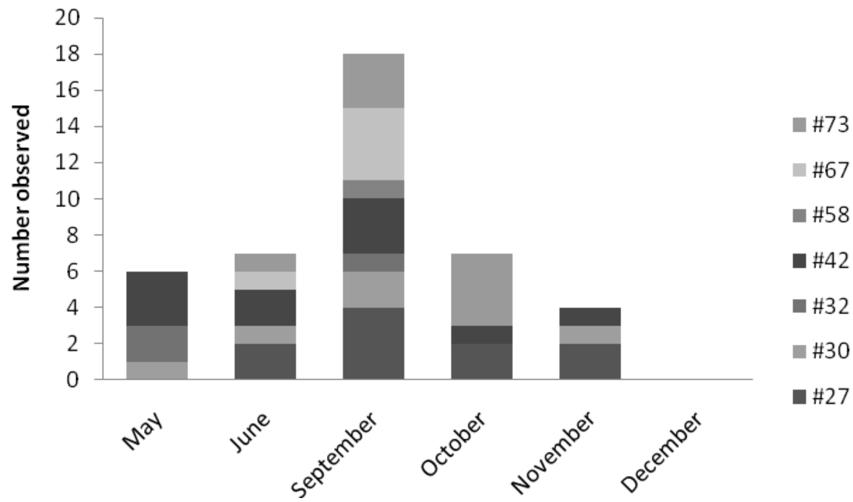


Figure 3. Number of wildlife observations according to the months of data collection

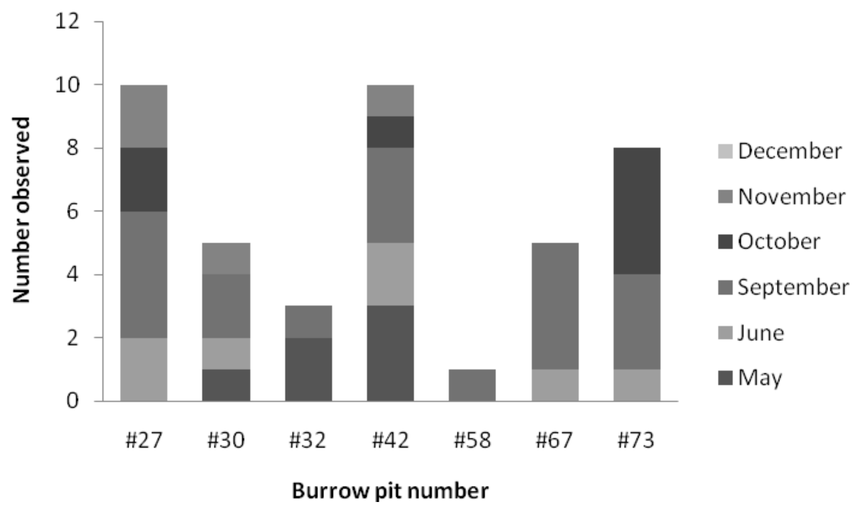


Figure 4. Number of wildlife observations according to the selected Burrow pits

Conclusions

Three species were the most dominated observed during road patrols. These included the Grey-winged trumpeters, Black currosow and Red-rumped agouti. Wildlife observations on the road may depend heavily on the number of vehicles using the road, availability of food and their use of the road as a crossing.

A mild pattern of the relationship between the number of vehicles and birds recorded on bird transect patrols was observed in May-June and November-December. However, this could also be related to weather influences.

The presence of elusive species such as the Jaguar and Tapir was heavily noted in the selected burrow pits, with observations exceeding 16 in September. The greatest number of observations was noted for burrow pits 27 and 42. The reasons for this may vary from weather conditions and availability of food.

4.3.4 Giant otter distribution and abundance

Background

The giant otter (*Pteronura brasiliensis*) is a top predator in neotropical freshwater ecosystems, and therefore represents an appropriate indicator species for changes in fish populations and anthropogenic disturbance. Remaining giant otter populations are threatened by rapid development and commercial fishing across South America. In Guyana the recent use of gill nets and other non-traditional methods of fishing, coupled with population increase and expansion in the interior brings associated pressures to fish stocks and the species that rely on them. Giant otters consume up to 3 kilograms of fish per day, and therefore conflicts between these large hunters and fisherman are likely. In addition, increasing human disturbance from gold and diamond mining along rivers may affect otters in several ways, including water pollution and general disturbance.

In 2002, giant otter occupancy distribution surveys were conducted along the main rivers across the North Rupununi. Otter occupancy surveys were conducted again in 2009 to provide a temporal comparison and updated baseline for monitoring. These more recent surveys were restricted to the rivers within the Iwokrama Forest area, and therefore comparisons in this report are also restricted to these areas.

Study area

The Iwokrama Forest is drained by the Essequibo River and two smaller rivers, the Burro-Burro and Siparuni, that are briefly confluent before joining the Essequibo. It is bordered to the east by the Essequibo River and to the north and west by the Siparuni River. The Burro-Burro River runs through the central part of the Iwokrama Forest. In the vicinity of the Iwokrama Forest the Essequibo River has main channels 250-500 metres wide and is at maximum approximately 1 km wide. It is characterized north of Kurupukari Falls by extensive sand bars that are visible during low water and in several places throughout the Iwokrama Forest is crossed by volcanic dykes forming rapids. The Essequibo has a probable maximum depth of 40 m, and its banks are not high except where scouring has occurred. The Essequibo drainage is seasonally linked to the Amazon drainage when the flooded savannas form a continuous expanse of water between the tributaries of the Rio Branco and the Rupununi River. The Burro-Burro and Siparuni Rivers are much smaller rivers with maximal widths of 100 m and 150 m respectively. As in the Essequibo, rapids are formed where the rivers cross over volcanic dykes. Both the Burro-Burro and Siparuni rivers are steep-sided, deep rivers with few sandbars, and little exposed shoreline. The Essequibo River has far more sand and silt substrates than do either the Siparuni or Burro-Burro. The Burro-Burro River floods extensively into the forest during the rainy season.

The Essequibo has high sediment loads and can be considered as a white water river along its borders with the Iwokrama Forest. This is partly due to the fact that the white water Rupununi River drains into the Essequibo just south of the Iwokrama Forest. Secchi disc visibility ranges from approximately 0.2 to 1.0 metre in the main channels. Despite this, water colour and turbidity change seasonally and spatially, sometimes appearing much like what is considered to be black water. Changes in the relative contributions from the different tributaries can substantially alter the waters of the Essequibo near the Iwokrama Forest. The Burro-Burro and Siparuni are predominantly black water rivers, with the Siparuni being slightly darker; however the transparency of these rivers is highly variable. All of the main rivers are fed by small third order creeks which are more definable as black, white, or clear waters.

Methods

Occupancy distribution surveys were carried out along the three main rivers, and in adjacent ponds, lakes and larger creeks within the Iwokrama Forest area. The locations of all camp sites, dens and latrines were recorded using a GPS. The current use status, based on the occurrence of trampled plants and recent latrines use was recorded. Records of the length, width at the entrance, height inside the den, and distance from the water of these sites was also taken. A total of 250km of river was covered over a three week period in November and December 2009. Surveys were conducted by local Amerindians who spend much of their time on these rivers.

Campsites are patches of land on the banks of water bodies, which are used regularly for defecating, scent marking, drying out, grooming and resting by giant otters. They are also often associated with cross-over points (locations where giant otters habitually take short cuts over land) between a river and a nearby lake, or across a river bend. Within each campsite there are one or more latrine areas of varying freshness, often on the periphery of the site, characterised by the presence of scales and other hard fish remains. Defecation and urination on the latrine may be, followed by thorough trampling and mixing of the scats. A campsite may be used once only, or for multiple years. When very fresh, the campsite's odour is powerful and fishy and may attract large numbers of insects. The substrate is damp or muddy, and nearby vegetation is usually damaged Pools of urine may be present, and fish discards are common. As the days pass (and the campsite is not re-visited), insect activity gradually decreases and the smell becomes less pronounced. With increasing age, fish scales become separated and are dispersed by insect and bird activity and rain, the smell becomes mustier and leaf litter starts to accumulate. Trampled twigs and leaves desiccate. As the weeks pass, scales become brittle and are broken down more readily, lose their transparency and become opaque or yellowy in colour. Within a single territory there may be many campsites and dens but only a small number are actually being used at any one time.

A den consists of one or more tunnels leading to one or more oval chambers excavated into the bank. Dens are communal, used for sleeping and/or cub rearing, and are frequently located under root systems or fallen trees. A fresh den is indicated by moist, trampled vegetation, a muddy slide or concave path, and/or numerous tracks that lead from the entrance directly to the water's edge, and usually at least one latrine that is located in the immediate vicinity. In addition to this latrine, there may be a separate campsite. Some families may spend several consecutive days or weeks in the same site.

Results

Essequibo River – Siparuni mouth to Ladysmith Creek

Surveys were conducted from the mouth of the Siparuni River to Ladysmith creek at the south-eastern boundary of the Iwokrama Forest, equal to 123km of river (Fig 1). A large proportion of the island banks in the Essequibo were surveyed where water levels enabled boat travel. Giant otters were more often present in areas where the river was deeper. Two giant otter sightings were obtained, consisting three and one member respectively, but many known groups were not observed during the survey period. Twelve active dens were detected (Fig 1a), and these fitted a slightly clumped distribution. Active den encounter rate was approximately 1.0 per 10km of river (see Fig 1 and Table 1).

Siparuni & Burro-burro Rivers

The Siparuni River survey area was from the mouth, to approximately 10 km upriver from the Ireng Creek (Fig.2). No signs of habitation by otters were detected, and just one group sighting of three individuals confirmed that giant otters use the area. Active den encounter rate was therefore 0 (see Fig 2 and Table 1).

The Burro-burro River survey area was from the mouth to approximately 10km upriver from the area known as 'Sandstone'. Five active dens were found, but it is difficult to estimate how many families this may relate to. Active den encounter rate was 0.6 per 10km of river (see Fig 2 and Table 1).

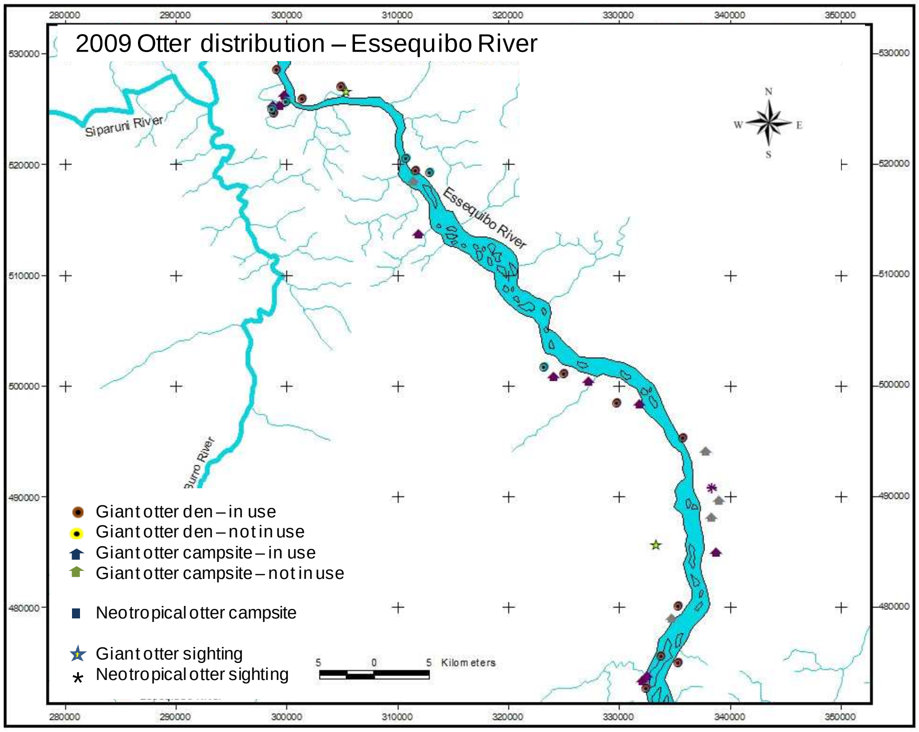
All rivers

The total survey area comprised 251km of river. Seventeen active dens were detected, yielding an active den encounter rate of 0.7 per 10km. A total of seven families of giant otters were observed and comprising 25 individuals altogether. Based on the number of active dens, and low detecting probabilities, it is likely that only a fraction of giant otter groups were observed, particularly in the around the Essequibo island networks.

Population estimation

It is normally considered that giant otter density cannot be deduced from distribution surveys based on signs not sightings. Therefore, in this case no attempt should be made to calculate densities due to variations of otter fidelity to dens and campsites. Due to the low numbers of otters encountered, it is difficult to extrapolate actual population figures, however for the purpose of monitoring this is not necessary. These surveys were designed to compare relative abundance with surveys conducted in 2002 (see Table 1).

(a.)



(b.)

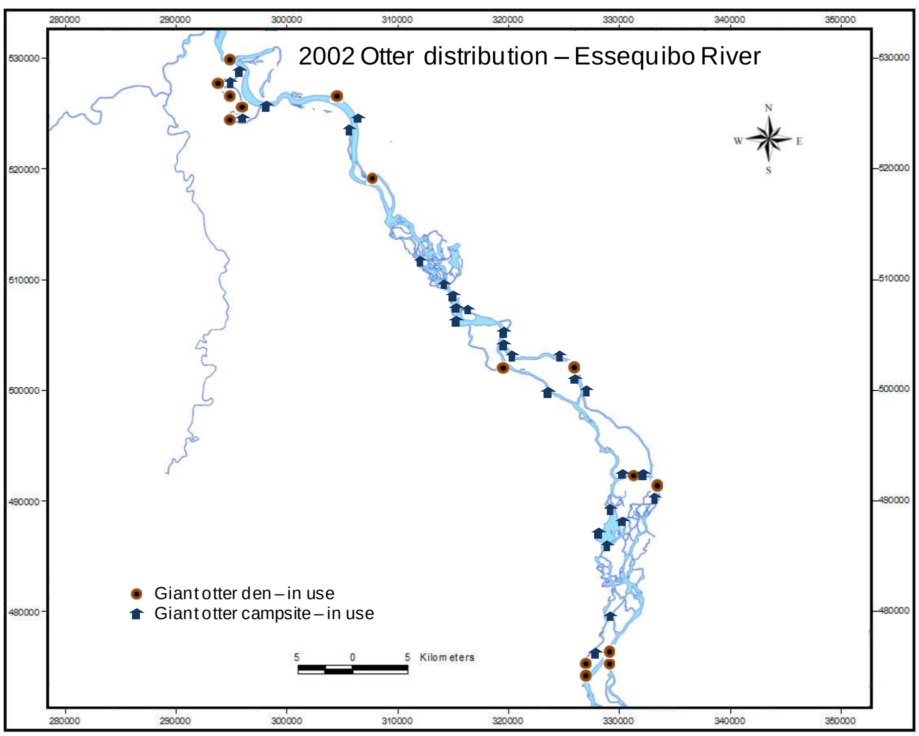


Fig. 1. Essequibo River otter den and campsite distribution in (a.) 2009, and (b.) 2002. Only the survey area is shown on this map.

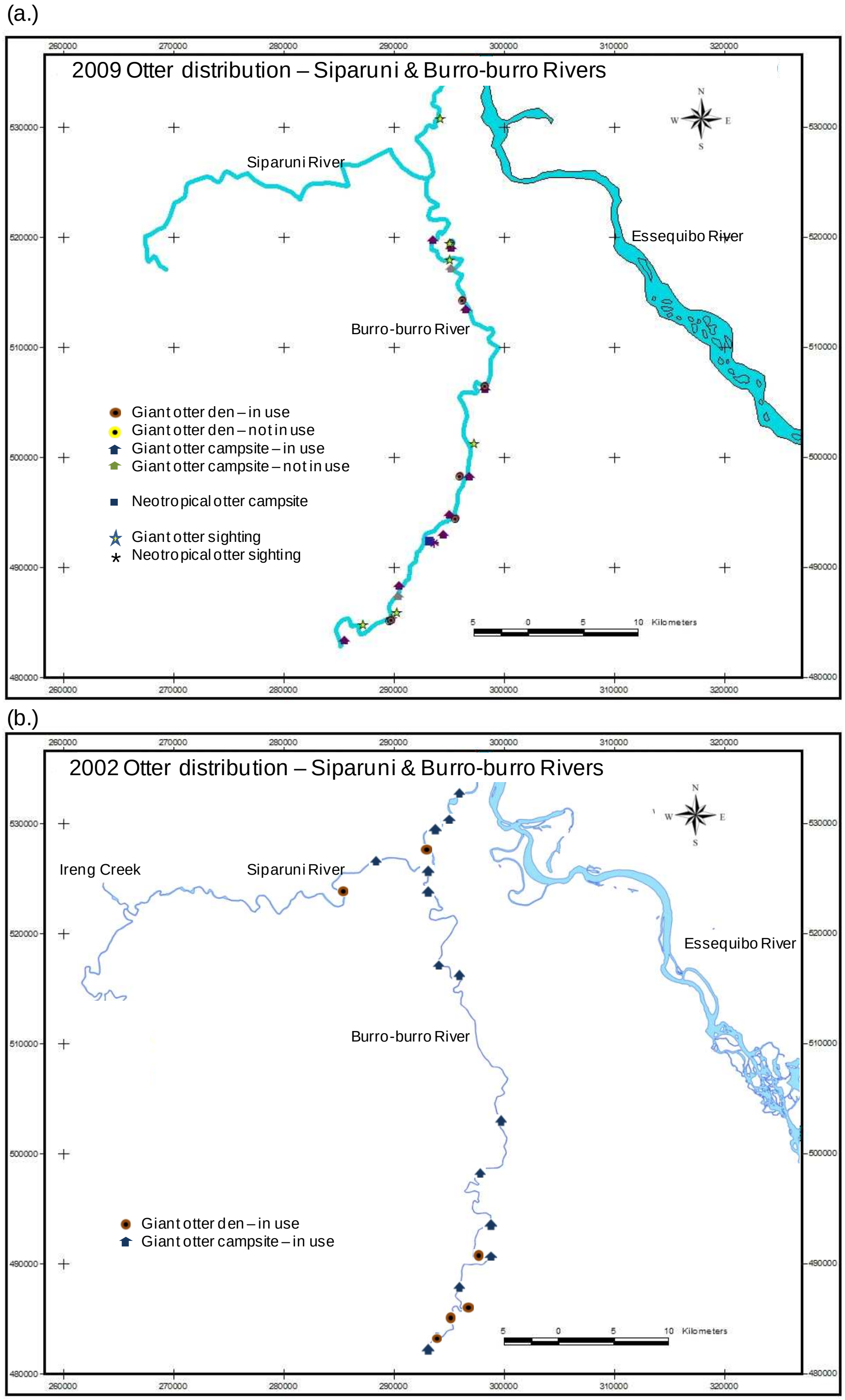


Fig. 2. Siparuni and Burro-burro otter den and campsite distribution in (a.) 2009, and (b.) 2002. Only the survey area is shown on this map.

Table 1. Numbers and encounter rates of active (in use) giant otter dens and campsites in the Essequibo, Siparuni and Burro-burro Rivers in 2009 and 2002.

	Essequibo	Siparuni	Burro-burro	All
Distance surveyed (km)	123	45	83	251
Number of active dens				
2009	12	0	5	17
2002	15	2	4	21
Number of active campsites				
2009	10	0	9	19
2002	28	4	10	42
Active den encounter rate/10km				
2009	1.0	0	0.6	0.7
2002	1.2	0.4	0.5	0.8
Active campsite encounter rate/10km				
2009	0.8	0	1.1	0.8
2002	2.3	0.9	1.2	1.7

Discussion of temporal differences

Active giant otter den encounter rates in the Essequibo and Burro-Burro Rivers have remained relatively unchanged since 2002. However in the Siparuni den numbers have dropped from two in the survey area in 2002, to zero in 2009. It is probable that this change reflects pressures caused by increased mining activities in the Siparuni area during this period. While mining is uncommon within the Siparuni itself, there is now an established mining community in the area of the Ireng Creek (Fig 2b). This community is supplied by regular boat transport, causing disturbance much greater than in most of the remaining survey area, as well as increased pressures on fisheries resources by elevated human population densities. Additionally, run-off from the mining activities into the Ireng Creek, and subsequently into the Siparuni may be associated with water pollution and increased sedimentation that may affect otters. Tests in 2009 showed that mercury was not filtering into the Siparuni system.

Active campsite numbers in the Essequibo were much lower in 2009 compared with 2002, however as mentioned above den numbers were similar. It is therefore likely that observer bias may have influenced the numbers of campsites classed as active. Active campsite numbers in the Siparuni reflected the change in the numbers of dens in the Siparuni also, with a drop from four to zero.

Conclusions
With the exception of the Siparuni drainage, the giant otter population in rivers within the Iwokrama Forest area appears to have remained stable since 2002. However, given the apparent changes in otter distribution in the Siparuni, efforts should be made to reconcile the impacts of increased human activity in these areas.

4.3.5 River wildlife

Background

Water fowls like the river otters are an indication of water quality and the health of freshwater ecosystems. The seasonal activity patterns of the fauna of many Neotropical forests are extensively linked to changes in the water level in the river system. Along with this and increased silt deposits in flooded forests are often focus for animal movements and migrations. There are three main rivers and numerous minor rivers that border and are within the Iwokrama reserve. Two of the main rivers are public access, therefore, exposing wildlife to hunting.

Methods

Routine patrols are conducted three times a month at unscheduled times, twice downstream with one overnight trip and one upstream of the Iwokrama River Lodge. River patrols begin at 0700 hrs. Observations of targeted species are recorded. Bird transects are additionally used to monitor populations of target bird species.

General

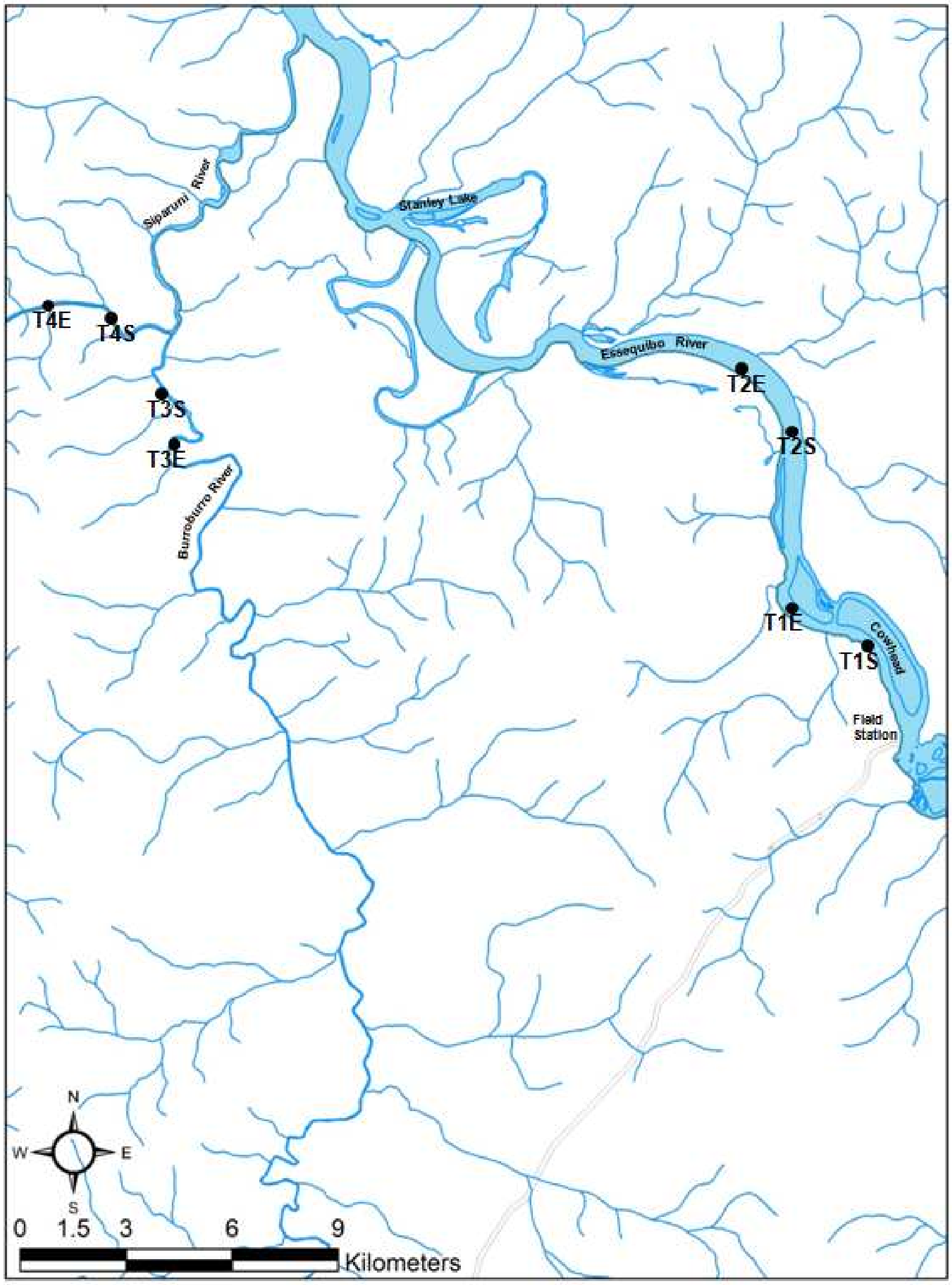
- During all river patrols, sightings of target species (see Table 2) are recorded.
- Between transects the boat travels no greater than 30kph observing for target species at all times.
- Upon detection of target species, their location, group size and any available demographics are recorded.

Bird transects

- Bird transects are pre-defined three upstream and four downstream (see Table 1 and Figure 1)
- The boat travels at a pace no greater than 5 km/hr (measured with GPS), for a distance of two kilometres (except at Ladysmith creek).
- Observations are made for target bird species. Binoculars must be used at all times, and a bird identification book used to verify species.
- Observers pay special attention to the river bank where small river associated birds are often active (such as kingfishers).

Table 1. River patrol bird transect locations and survey times.

Location	UTM	Time start	Notes
Downriver			
Cowhead start	X 312527, Y 518664	0700-0730	
Cowhead end	X 310699, Y 519458		
Paddle rock start	X 310351, Y 524469	0730-0830	
Paddle rock end	X 309358, Y 526114		
Burro-burro start	X 292831, Y 525682	0930-1030	
Burro-burro end	X 293008, Y 524231		
Siparuni start	X 291418, Y 527580	1030-1130	
Siparuni end	X 289697, Y 528159		
Upriver			
Kolotocker start	X 319347, Y 509692	0730-0830	Just upriver of small falls
Kolotocker end	X 319974, Y 507798		
Pitchum pitchum start	X 335381, Y 490702	0900-0930	Just downriver of small falls
Pitchum pitchum end	X 334663, Y 488843		
Ladysmith creek start	X 332314, Y 471296	1030-1130	Mouth of the creek
Ladysmith creek end	X 332181, Y 470629		As far as water level allows



Section 1: Downriver

Bird transect 1: 'Cowhead' -	Start X 312527, Y 518664
	End X 310699, Y 519458
Bird transect 2: 'Paddle rock' -	Start X 310351, Y 524469
	End X 309358, Y 526114
Bird transect 3: 'Burro-burro' -	Start X 292831, Y 525682
	End X 293008, Y 524231
Bird transect 4: 'Siparuni' -	Start X 291418, Y 527580
	End X 289697, Y 528159

Figure 1. Bird transect locations downriver from the Iwokrama River Lodge.

Baseline data

The total distance covered for birds transects along the river were 54km upstream and 96km downstream. Upstream data was recorded for the months March 2009, May 2009 – January 2010. Downstream data was recorded for the months March 2009 – Febraury 2010. Sighting rates are calculated as follows;

$$Sighting\ rate = \frac{Number\ seen}{Distance\ travelled\ (km)}$$

General

Table 2. Target species for all river patrols and the numbers observed

Taxa & Species	*Scientific name*	Upstream	Downstream
Mammals			
Giant river otter	*Pteronura brasiliensis*	20	22
Neotropical river otter	*Lontra longicaudis*	1	0
Fish			
Arapaima	*Arapaima gigas*	0	0

Bird transects

Table 3. River monitoring bird transect target species and the numbers [N] and sighting rate [SR] observed

Family & Species	*Scientific name*	Upstream		Downstream	
		N	SR	N	SR
Kingfishers					
Amazon kingfisher	*Chloroceryle amazona*	9	0.5	23	0.1448
American pygmy kingfisher	*Chloroceryle aenea*	0	0	1	0.0056

Ringed kingfisher	*Megaceryle torquata*	13	0.2166	15	0.1022
Green & rufous kingfisher	*Chloroceryle inda*	4	0.1	11	0.0795
Pygmy kingfisher	*Chloroceryle aenea*	2	0.0333	1	0.0028
Tiger-herons					
Rufescent tiger-heron	*Tigrisoma lineatum*	2	0.0333	0	0
Herons & egrets					
Great egret	*Ardea alba*	8	0.1333	8	0.0596
Cocoi Heron	*Ardea cocoi*	31	0.5166	21	0.1477
Little blue heron	*Egretta caerulaea*	3	0.05	3	0.0227
Tri-coloured heron	*Egretta tricolor*	2	0.0333	0	0
Ibis					
Buff-necked ibis	*Theristicus caudatus*	0	0	0	0
Green ibis	*Mesembrinibis cayennensis*	6	0.1	12	0.426
Ducks					
Muscovy duck	*Cairina moschata*	25	0.4166	36	0.3465
Swallows					
White-winged swallow	*Tachycineta albiventer*	81	1.35	294	2.1333
White-banded swallow	*Atticora fasciata*	16	0.2666	23	0.2159
Terns					
Large-billed tern	*Phaetusa simplex*	10	0.1666	6	0.284
Other					
Anhinga (snake bird)	*Anhinga anhinga*	28	0.4666	15	0.1136
Neotropic cormorant	*Phalacrocorax brasilianus*	37	0.6166	9	0.0681
Osprey	*Pandion haliaetus*	5	0.0833	4	0.0397
Black Skimmer	*Rhnchops niger*	0	0	22	0.2045

Conclusions

The Giant River Otter was most commonly observed during river patrols both upstream and downstream to the Iwokrama River Lodge in proportionate numbers. This may be due to their migratory behaviour. Differences in the number of at least four species in upstream and downstream observations were noted. These included the Amazon kingfisher, White-winged swallow and Black skimmer where increased numbers were observed downstream and the Neotropical cormorant where there was a higher number observed downstream. This may be the result of availability of food or water levels, however, data gathered over an extended period will allow for deeper analysis..

4.3.6 **Burro Burro River Monitoring**

Background

The Burro Burro River passes through the Iwokrama Forest and extends from the Siparuni junction into Surama. This makes it critical to monitor as it is accessible by the public. The Surama community members have a wealth of information about the river and wildlife that inhabit them. Utilisation of this information is critical and can assist Iwokrama greatly and thus the signing of a MoU that formed a partnership between Iwokrama and Surama Village to monitor the River.

Methods

Patrols are done quarterly and in and informal manner. The team mainly comprises boat captain, Fred Allicock, bowman, chainsaw man. The patrol team selects the best week for the trip in the quarter depending on the water level. The team departs the landing in Surama at dawn of the first day of a five day trip depending on the water level and amount of debris in and across the river. The team proceeds downriver observing wildlife, clearing the river of debris, and making observations of presence of illegal hunting and fishing.

Baseline Data

Information presented is based on two patrols done in May and August 2009

May

Waypoints for sites of cultural, tourism and other important uses were recorded. Debris was cleared from the river including large trees in the river and hanging vegetation. Several camp sites along the river, including Nakabea and Shana landings, were visited and observations of wildlife and human presence were made.

The Sandstone camp site was noted as being in need of repairs and clearing as it was infested with termites and the immediately surrounding area is heavy with vegetation. Observations of litter and freshly burnt fires indicated human presence at the site. It should be noted that this was not the presence of IIC monitoring team. The camp site was cleaned before the team departed.

August
Wildlife observations were made and debris cleared from the river. The camp sites were again visited and observations of wildlife noted. Four fishermen were observed at Arawana Creek with smoked fish in their possession. Observations of otters and other wildlife were made at Bush Cow Camp and Alligator Creek respectively. An Oreinated Eagle was also observed and a nest suspected to be on the bank of the Burro Burro River. The team noted a significant increase in the number of wildlife observations;

“Many species of fish, birds and other animals were observed during trip in comparison to previous trip”- quote from Gendon Allicock, Surama Village Report

Conclusion

The Burro Burro River patrols have proven to be of significant importance for an indication of illegal activities and change in wildlife presence. The patrols are being done by community members who have a wealth of information about the river and it’s inhabitants and can therefore give a good idea of their change in presences. However, in order to allow this information to be better captured the river patrol monitoring system being used at IIC will be introduced in 2010. This will allow for a standard system with the two teams and allow for a more scientific anaylsis.

4.3.7 **Additional Studies**

The project was able to support 2 Masters level students from the University of East Anglia.

Will Birkin’s study- Is logging creating habitat for breeding frogs in dry season?

Abstract

The activity of logging impacts upon a forests’ flora and fauna. Many anuran species can experience decline, others an increase in their populations. This study considered a mechanism by which anuran species may experience population increases as a result of selective logging. The creation of ponds on skid trails, increasing available breeding habitat, particularly in dry season. It was found that skid trails created ponds which were used by breeding frogs and would not be present in pristine forest in dry season. Skid trail ponds were a preferred breeding site to creek-side ponds. It may be the risk of flood scouring in creek side pools, accounts for this difference. Leaf litter content of a skid trail pond is the only abiotic variable which influences tadpole species richness and abundance. One species *Dendrosophryniscus minutus* has a preference for ovdepositing in ponds with a small volume. Other anurans had no preference for breeding in ponds with particular characteristics. The study shows ponds are created by skid trails, they persist in dry season and are used by a number of pond breeding species. More extensive studies of both larvae and adults, could provide further evidence as to the importance of skid trails in enhancing the populatons of particular anuran species in logged forest.

Simon Phelps's Study- Effects of tree-fell gaps caused by reduced impact logging (RIL) on dung beetle fauna of the Iwokrama Forest, Guyana

Abstract

Reduced-impact logging (RIL) is a potential solution to slowing the loss of biodiversity associated with conventional logging methods. The effects of RIL on invertebrates have not been examined, particularly dung beetles which are known to be very sensitive to changes in forest structure and microclimate. This study examined the influence of RIL on the dung beetle community of a tropical lowland forest in central Guyana, South America. Pitfall traps and flight interception traps (FIT) were used to sample dung beetles in four different treatments: canopy gaps in logged forest, closed canopy in logged forest, canopy gaps in unlogged forest and closed canopy in unlogged forest. Five replicates were made, resulting in 20 sites being sampled over a 6 week period during the dry season. Thirty-four species and 1290 individuals were caught over a period of 480 trap nights. Species richness, abundance, diversity (H') and evenness was similar between logged and unlogged forest. Two species showed significant responses to logging: *Hansreia affinis* showed a preference for logged forest, whilst *Canthidium sp.2* was virtually excluded from the logged forest. Dung beetles were shown to prefer the cooler conditions beneath the closed canopy, which explains why they also preferred the edge of canopy gaps over the centre. This research shows that RIL does have a reduced-impact upon the biotic community and consequently should be implemented across the tropics.

5 Pressures/Resources

5.1 Timber Harvesting

Iwokrama operates a sustainable timber harvesting operation in partnership with local communities and a private sector partner, Tigerwood Guyana Inc. The net operable area (NOA) of 108,000 hectares represent only 29 percent of the Iwokrama Forest. A 60 year cycle is applied and other stringent regulations of the Guyana Forestry Commission and Reduced Impact Logging is applied. Iwokrama's operations was FSC certified in January 2008.

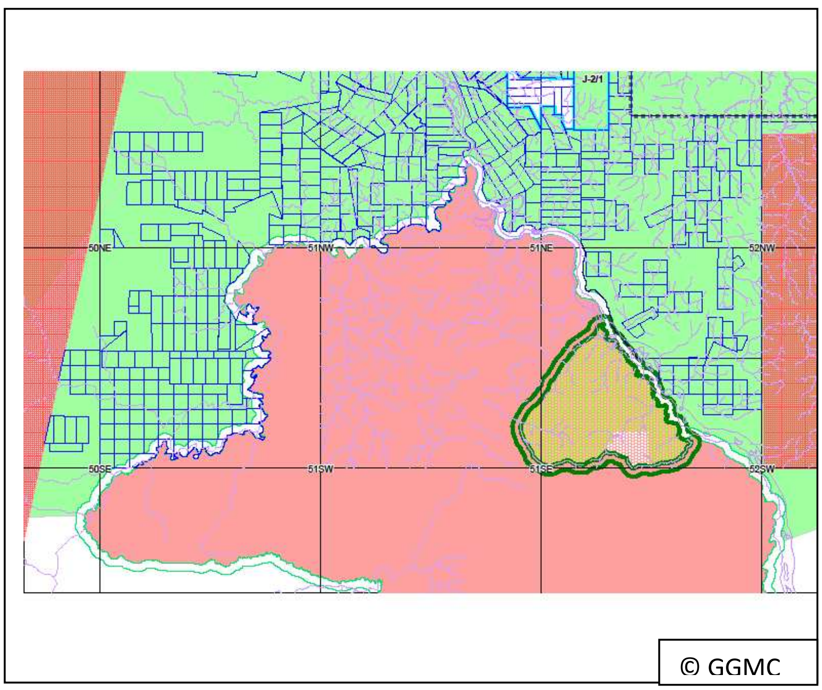
The maximum off take per annum allowed is 20,000 hectares. The extraction done since February 2007 when the operation commenced is:

2007 – 3,634 m3
2008 – 8,790 m3
2009 – 14,003 m3

The Post-Harvest Forest Impact Surveys will address impacts of forestry activities on biodiversity. Ref: Section 4.2.2 which has done Pre-harvest surveys.

5.2 Mining

Iwokrama does not allow mining within the forest. Mining claims have been given out on the right banks of Essequibo and Siparuni Rivers (see Figure below) Gold mining is occurring in Siparuni within the Demerara Timbers Limited concession.



An assessment of mercury pollution was done by student, Will Birkin, from University of East Anglia, UK, along the Ireng creek where mining was occurring (on other side of Iwokrama).

He found that that there were a number of mining dredges along Ireng Creek, 10 found at least 8km upstream from the creek mouth of the Essequibo River. He assessed whether mercury was present in creek pools along either side of Ireng creek and two adjacent creeks, one upstream and one downstream. He tested all creek side pools with an area greater than $0.25m^2$. He tested all pools present from the mouth of the creek, to at least 200m upstream from the mouth. He placed the pollution sensitive area of the colour metric test strip into the creek pool. He moved the test strip in the water, removed it and matched any colour change to the mercury colour test strip key.

Results

He found mercury present in two creek side pools at the lowest detectable level on the mercury colour test strip key, less than 50mg/l. This indicates that it is unlikely that significant concentrations of mercury are entering the Essequibo River in the Iwokrama Reserve. However, he did not test the creek directly. Also, variables such as seasonality would need to be considered to gain an accurate picture of the mercury transported annually from mining dredges downstream to the creek mouth and the Essequibo River.

5.3 Hunting and Fishing

Background

Iwokrama has, for a long time, a close relationship with the communities of the North Rupununi. As a result of this and their inherent right, community members are welcomed to gather non timber forest products, fish and hunt for subsistence use within the Iwokrama Forest. A monitoring system is set up at the Southern boundary of the Forest (Corkwood Ranger Station), since this is the entrance used by community members. The information gathered will assist Iwokrama in identifying the main species utilised, key fishing sites and give an estimate of the species populations as well as changes in community use.

Methods

- The Check Point monitor at Corkwood Ranger Station collects and records the following information from community members as they exit the reserve, Species (Common name), number caught, weight, origin of catch and fisherman.
- The information is recorded in a designated log book.

Baseline Data

The data presented covers the period of systemised data collection beginning April to December 2009. It should be noted creeks within the reserve were observed as being low to very low in the latter half of the year. There was only one recording of two bush hogs in September. These together weighed approximately 60kg and were found within Kuipari Creek area.

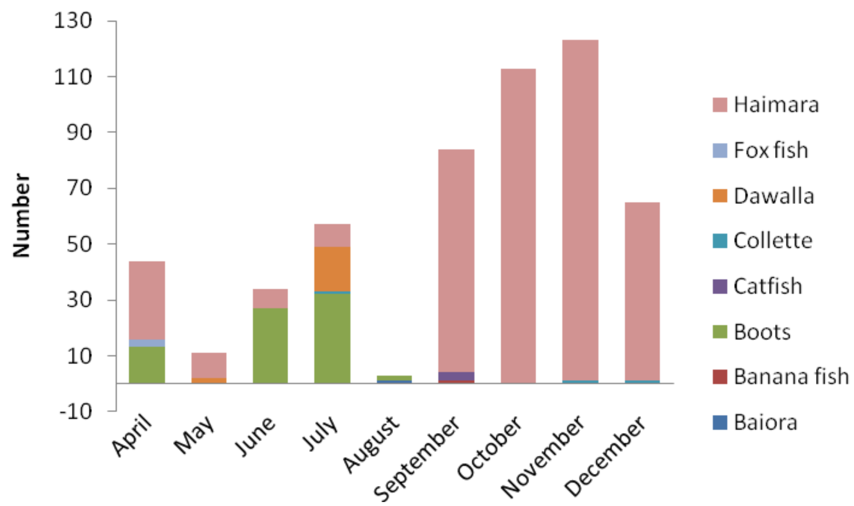


Figure 1. Showing the total number of fish harvested by species and month

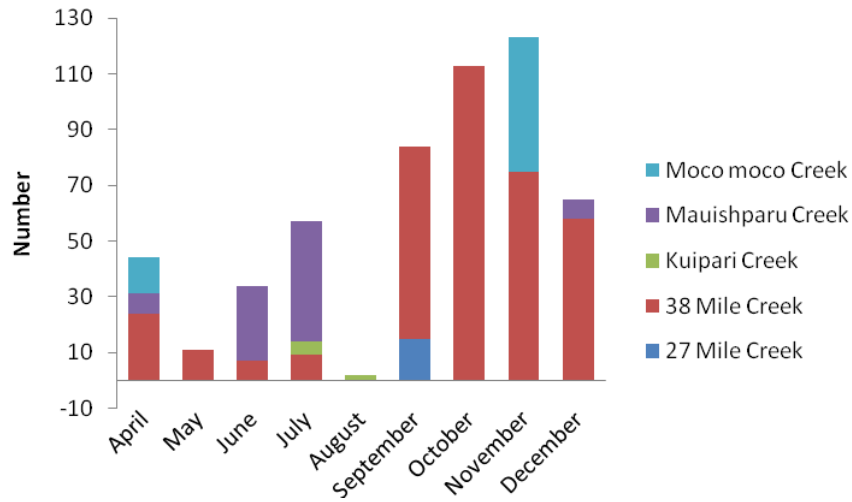


Figure 2. Showing the accumlative number of fish caught for the period according to origin of catch.

Conclusion

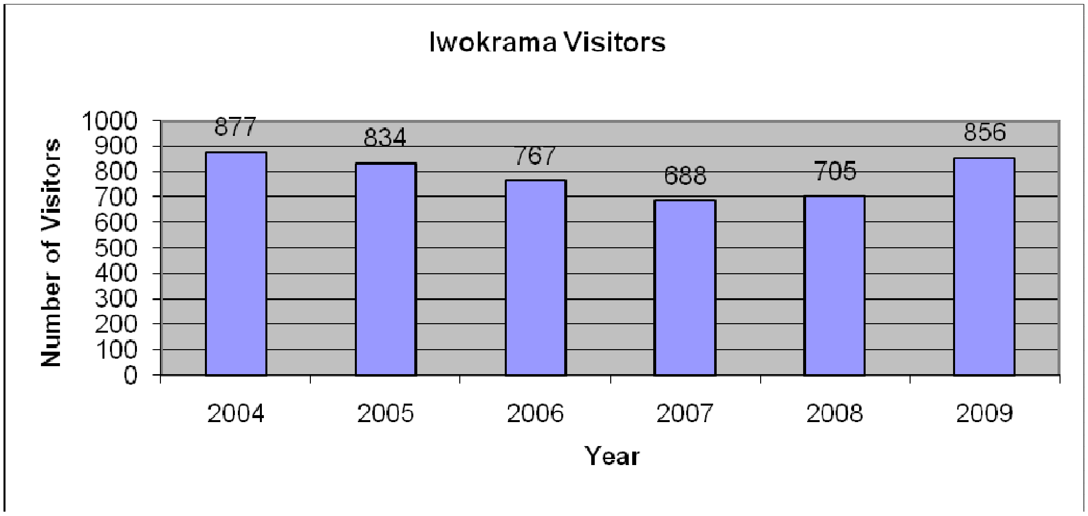
The significant increase in the number of fish extracted for the later quarter of the year may be the result of several factors including weather and financial conditions. There was a noted extended dry period in 2009 which may have influenced communities to increase extraction within the Iwokrama Forest as many creeks in the North Rupununi were extremely low to dry for this portion of the year. A decrease in the water level for the five creeks frequently visited may also have increased the ability to extract fish during this period.

In addition to this a continuous increase in extraction rate could be an indication of change in community needs as a result of an increase in population. This may also result in increased financial requirements and thus extraction for commercial purposes.

However, a longer period of data collection will allow for the several parameters to be better analysed with respect to their influence on the extraction rate including change in weather patterns and community demographics.

5.4 Ecotourism

Tourism at Iwokrama is low impact and an average of 789.5 visitors per annum has been maintained over the past six years (see Figure below).


Iwokrama Visitors
Number of Visitors
1000
900
800
700
600
500
400
300
200
100
0
877
834
767
688
705
856
2004
2005
2006
2007
2008
2009
Year

6 Synthesis and lessons learned

The GSI project has been a great support to the maintenance and development of the Iwokrama Monitoring Programme including the upgrade of Iwokrama's Monitoring Framework. Additional equipment was sourced and support for additional staff provided.

The support for water quality, climate and hydrological monitoring was critical as this is an area that is of great need for Iwokrama and Guyana. For the first time data is now being collected routinely on water quality along the main rivers of Iwokrama and a system is now in place for monitoring of water quality of creeks that drain the current harvesting areas.

The GSI project also benefited from the establishment of a long term climate and hydrology monitoring system which Newcastle University is a main partner with IDB being the main donor. There is little climate and hydrology data collected in the interior and this system will capture data for both forest and savannah ecosystems. And important aspect is also data capture for the transition zone between forest and savannah.

The project met all objectives of this contract as impacts of the timber operations and other uses of the forest in particular public road use and river use (which are outside of Iwokrama's control to an extent) need to be assessed.

- The preservation of the biodiversity in relation to the management of the site- the biodiversity- the forest impact surveys, road and river monitoring, permanent sample plots, otter surveys serve capture these elements
- Climate regulation, the preservation of carbon stock of the site and the sequestration of carbon dioxide by the forest of the site- estimates have been made on carbon stocks, and climate monitoring is now in place in collaboration with Newcastle University.
- The maintenance of the hydrological services provided by the site (quality and quantity of surface and ground waters); contributions through evapotranspiration- hydrological monitoring is very limited in Guyana and this project has supported the installation of system that will capture these aspects- water quality, flows etc.

Recommendations

It must be recognized that monitoring is a long term process if impacts are to be truly determined. For example the contract period was too short to support post harvest forest impact surveys (faunal) or remeasurement of permanent sample plots (floral). In order to make use of this work adequately another phase would enable Iwokrama to carry out this kind of work to ensure that concrete analyses can be done to inform management and business decisions and also serve as a model for Guyana and other parts of the globe.

Also further work is needed in areas of assessing mining impacts on the Iwokrama, although mining is out of Iwokrama's control.

Public access to this protected space also makes it increasingly important to widen Iwokrama's monitoring range. For example it is now becoming increasingly necessary for build a Ranger Station at the junction of Burro Burro and Siparununi rivers as there have been reported incidents extraction of wildlife including fish, for possible commercial purposes. This would also mean that more boats, rangers and related monitoring equipment would be needed.

The relationship developed with Surama Village to co-monitor the Burro Burro is a good example of how co-management of forest resources can work. More support in terms of implementation of monitoring is needed for communities including capacity building and related equipment and supplies

Water quality testing needs to be increased to capture a wider range of influences particularly weather conditions. The hydrological cycle also needs to be studied in greater depth and how this feeds back to the climate system and vegetation interactions. This is great importance to Guyana (and global value as well) as much work has not be done especially as it relates to forests and savannah ecosystems.

Future tourism impacts also need to be assessed.

In terms of ecosystem services, a good start has been made but more research in quantification and valuation is needed. Many studies focus on above ground biomass but there limited knowledge on below ground biomass and nutrient cycling.

For many of these recommendations supporting the upgrade of research facilities at Iwokrama, the University of Guyana and other institutions would be necessary.

In conclusion, Iwokrama is happy to be a part of this project and the results clearly show that much has been accomplished over the years making this an institution with many lessons to share. There is also much to be done in terms of this topic on ecosystem services. The concept of ecosystem services having a saleable value provide vast opportunities and Iwokrama, with its innovative mission, is well placed to be a model for the world for this aspect as well as other current activities related to sustainable business development and conservation.