Mapping the Rupununi-Ireng biodiversity corridor between Amazonian and Guiana Shield watersheds

Interim Report to the Woodspring Trust

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Summary

The North Rupununi Wetlands are situated in the southern interior of Guyana, South America, and support a high terrestrial and freshwater biodiversity. Biodiversity surveys have identified more than 450 fish species, which in turn supply a food chain to endangered species such as the black caiman (*Melanosuchus niger*), giant river otter (*Pteronura brasiliensis*), giant river turtle (*Podocnemis expansa*), and recovering populations of the largest freshwater fish in the world, the arapaima (*Arapaima spp.*). These species are not only important for conservation but also supply local people with a range of livelihood activities, including subsistence fishing and ecotourism. There is increasing evidence that the high fish biodiversity of the North Rupununi Wetlands is in part as a result of a hydrological link between the Amazon and Essequibo basins, allowing species from both basins to intermingle in this region. The North Rupununi Wetlands are characterised by low topography and seasonal flooding of this watershed divide, thus allowing the migration of aquatic species, including arapaima and black caiman, which are found in no other watershed of Guyana. However, the precise location of these connectivity and migration corridors have not been studied to date.

Guyana is economically poor, and natural-resource exploitation and foreign pressure to convert natural habitats into industrial farms, logging, mining and oil wells, and associated infrastructure, especially access roads, is having increasing impact on the North Rupununi Wetlands. With this have come pollution, over-harvesting, irresponsible hunting, and unregulated or poorly regulated mining and logging that are resulting in the loss of species in general and habitat connectivity in particular. This has the potential to further deteriorate sustainable traditional livelihoods, already under pressure from globalization and the market economy, forcing many more Indigenous people to migrate to towns and cities in search of often poorly paid work.

Scientific proof, and detailed mapping, of the precise location and mechanisms enabling the hydrological link between the Amazon and Essequibo basins, would help support appropriate development and conservation in the region while at the same time provide new insight into South American aquatic biogeography. This hydrological link is colloquially named the 'Rupununi Portal'. The primary aim of our project was to locate and map the hydrological link and dynamics between the Amazon and Essequibo basins, collect proof of species movement across these basins, and disseminate the findings amongst Guyanese stakeholders in order to strengthen the conservation of the North Rupununi Wetlands.

The project used an innovative blend of traditional ecological knowledge, high-resolution aerial mapping, remote sensing analysis, participatory video, aerial videography and ground-based hydro-ecological surveys. This allowed us to precisely identify the spatial and temporal dynamics that allowed the waters of the Amazon and Essequibo basins to meet. This then enabled us to produce an engaging animation explaining this mechanism for public distribution. Our work also produced detailed vegetation, elevation and hydrological maps, which can support decision-making with regards to existing and proposed developments. We were also able to deliver a video filmed by Indigenous community researchers, representing the traditional knowledge, historical and current uses, and threats facing the hydrological link.

This information will support Indigenous communities, Guyanese conservation organizations and government policy makers in their quest for the sustainable management of the North Rupununi Wetlands, with a special focus on the Rupununi Portal region. The results will also help with the appropriate design of the upgrade to the Georgetown-Lethem road, which dissects the watershed. Finally, with the establishment of agri-industrial development in the region, there is the urgent requirement to minimise impacts on biodiversity and the Indigenous communities that depend on these for their livelihoods. We were able to directly contribute to informed decision-making with regards to a proposed Inter-American Development Bank agricultural project which, in its original configuration, would have resulted in one of the key spawning grounds of the 'Rupununi Portal' being destroyed through artificial flooding and agricultural development.

Research team and lead research institution

The research team was composed of the following:

- Principal Investigator: Dr. Andrea Berardi, The Cobra Collective, and The Open University (UK)
- Project Manager: Dr. Deirdre Jafferally, The Cobra Collective, and the Ministry of Amerindian Peoples Affairs (Guyana)
- Senior Research Associate: Dr. Matthew Simpson, The Cobra Collective, and Wildfowl and Wetland Trust Consulting Ltd (UK).
- Community Researcher and Coordinator: Felix Holden, Rupununi Wildlife Research Unit, Yupukari, North Rupununi, (Guyana).
- Community Dissemination and Outreach: Grace Albert, The Cobra Collective, and the North Rupununi District Development Board (Guyana)
- Transportation and logistics: Fernando Li, Rupununi Wildlife Research Unit, Yupukari, North Rupununi, (Guyana).

Although the research was carried out by individuals with distinct institutional affiliations, the actual project was managed through the Cobra Collective Community Interest Company (http://www.cobracollective.org/). This is a formally registered non-profit-making social enterprise based in the UK that has emerged from Project Cobra - an EU funded research project which took place in Guyana from 2011 to 2015. The Cobra Collective is constituted by an international membership and undertakes research, implementation, and training in the fields of development, nature conservation, health, natural resource management, social welfare, and education.

Introduction to the North Rupununi Wetlands

Geography and ecology

The North Rupununi Wetlands are situated in south-west Guyana (04º N 05’, 59º W 02’) (Figure 1). The region straddles the watershed divide between the Amazonian basin and the Essequibo River catchment. The area is dominated by three large rivers: the Rupununi, the Takatu, and its tributary, the Ireng. In this area, the three rivers pass within approximately 30 km of each other, separated by savanna, crisscrossed by a network of wetlands, small rivers, creeks, and lakes. The Rupununi River drains the central and eastern parts of the savannas and flows east into the Essequibo River, which drains into the Caribbean Sea. The Takatu and Ireng Rivers drain the western portion of the savannas and flow west into what is eventually the Amazon via the Rio Branco and Rio Negro (Figure 2).

Figure 1 Map showing the location of the North Rupununi Wetlands (red box) adjacent to the Guyana-Brazil border.

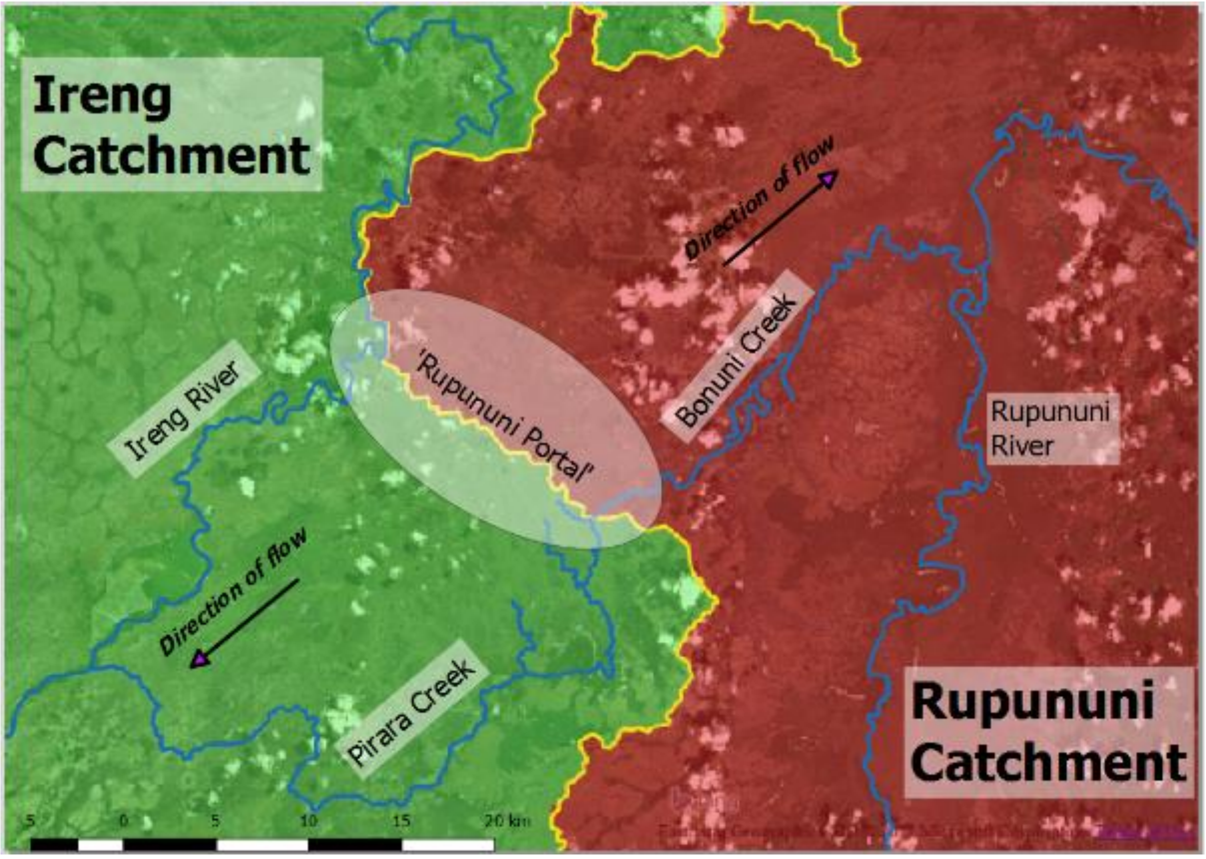

Figure 2 Map showing the watershed divide between the Ireng River (part of the Amazon basin) and the Rupununi River (part of the Essequibo basin). The 'Rupununi Portal' region indicates where the waters between the two basins are able to intermix.

The geology of North Rupununi region is complex due to its age. Early plutonic (a body of intrusive igneous rock) and volcanic rock formation, regional metamorphism, rifting, uplifting, and oscillating periods of sedimentary deposition and erosion have shaped the area into a patchwork landscape of varying geological characteristics. These processes have fundamentally influenced topography, soils, water flow, as well as the potential for commercial activities such as mining, agriculture and timber production. The close association between the Essequibo and Amazon basins in the region has ancient geological origins. 30/25 million years ago, an ancient river basin, called the 'Proto-Berbice' drained the Branco, Takutu, Ireng, Rupununi, Essequibo, Demerara and Berbice rivers into the Caribbean Sea. Over time, the Amazon basin gradually captured some of these rivers: the Branco 5 million years ago, and then the Takutu and Ireng 2 million years ago. Some researchers believe that the Rupununi will also be eventually 'stolen' by the Amazon from the Essequibo. These ancient geological shifts may have significantly contributed to the spectacular species richness currently present in this region.

Contemporary geological attributes also play a major role in creating a rich diversity of habitats, which in turn provides the opportunities for a great variety of species to thrive. Geology contributes significantly towards soil profile and structure. This has a key role in determining what vegetation is dominant and where they are distributed in the Rupununi. Soil profile takes into account several factors such as decaying matter, which determines how rich the soil is in terms of nutrients, and secondly the type of soil composition (i.e. sand, silt or clay) which has a role to play in the soil's ability to absorb and also retain water. The soils of the savannas differ from that of the rainforest region of the Rupununi in that they show low mineral/nutrient retention and water storage. Flora found in the North Rupununi are, therefore, specifically adapted for surviving in these conditions.

The geology also contributes to great variation in waterbody characteristics, including white, black, and clear water streams, foothill and mountain streams, dissected river systems and ox-bow lake formations. These wetlands are dominated by the Rupununi, Rewa, Essequibo Rivers, and a tributary of the Ireng River (Pirara Creek), and include over 750 lakes, ponds and inlets covering approximately 22,000 ha. The hydrology of the area is directly influenced by the Rupununi, Essequibo, Ireng and Takutu water catchments. However, it is the Rupununi River and Ireng catchments that are mostly responsible for the North Rupununi's unique transformation during the wet season (Figure 2).

The principal rainy season is from May to September, but with substantial year to year variation depending on the position of the Inter-tropical Convergence Zone (ITCZ) which meanders between northern Brazil and the Caribbean (Figure 1). During severe El Nino years, the ITCZ may not even reach Guyana, thus subjecting the region to severe drought, as occurred in 2015 and 2016. The total annual rainfall varies from 1,400 – 3,000 mm of which 50 to 70% falls during the main wet season. Approximately 8,000 km^2 of the North Rupununi savannas form a seasonally flooded plain during the wet season (the site of the legendary lake of El Dorado), rimmed on the north-west by the Pakaraima mountains, in the north by the Iwokrama mountains and in the south by the Kanuku mountains, allowing the Amazonian and Guianan Shield waters to mix, and effectively creating a water bridge between the two basins – the 'Rupununi Portal'. However, in 2015 and 2016, the rains were late, and no extensive flooding occurred, with severe impacts on biodiversity as aquatic fish species were limited in their spawning, and the resulting fry had a reduced area within which to feed and grow, with consequent impact on the local populations that depend on fishing.

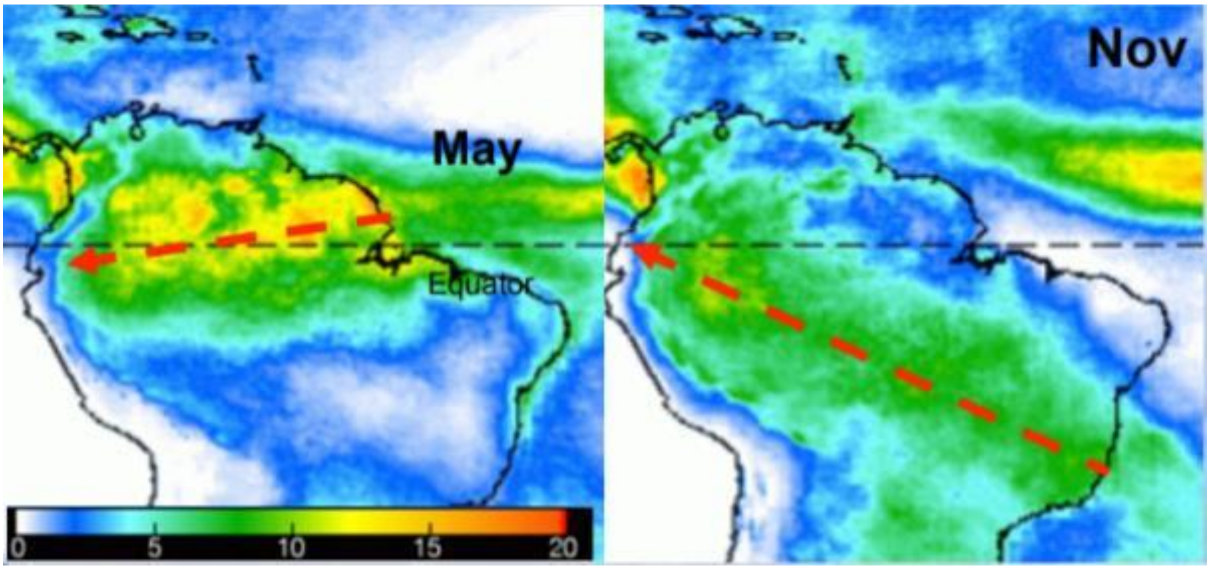

Figure 3: Position of the Inter-tropical Convergence Zone (dotted red line) in May (wet season) and in November (dry season). The map shows monthly average precipitation (mm/day) for 1998-2008 (after Bovolo et al, n.d.)

Flora and Fauna

The range of rainforest, savanna and wetland ecosystems present in the North Rupununi provide a unique and diverse selection of habitats for a rich biodiversity. It has been argued that the seasonal water bridge between the Amazonian and Guiana Shield basins represent a link for species and biodiversity, and is thus a key site for species migration, as well as providing an abundance of food, breeding grounds, and diverse habitats. Fishes, turtles and many native birds feed, breed and live in the wetlands all year round. At the same time, many species of migratory birds rely on the wetlands as feeding and breeding grounds. Flooding of these wetlands provides the opportunity for migration for fishes and other species of fauna that would have been otherwise isolated for a time of the year. Similarly, plant species are assisted by seasonal flooding by permitting seed dispersal.

Generally speaking, forest ecosystems support a higher abundance of plants and animals as compared to the savanna ecosystem. There have been over 1200 plant (Clarke et al, 2001, 141 amphibian and reptile (Donnelly et al, 2005) and 130 mammal (Lim et al, 2005) species documented in the Iwokrama Rainforest. The forested region of the North Rupununi area is generally mixed forest with no particular species dominance. These vary from tropical moist forest, tropical dry forest and at higher altitudes (on mountains and hills), tropical montane forests. These forests include important non-timber product species such as crabwood (*Carapa guianensis*) which is well known for the oil that is produced from its seeds used for medicinal and industrial purposes. Some common timber species include wallaba (*Eperua spp.*), mora (*Mora excelsa*), silverballi (*Ocotea spp*.), bullet wood (*Manilkara bidentata*) and greenheart (*Chlorocardium rodiei*). Kokrite (*Attalea regia*) and ite palm or tibisiri (*Mauritia flexuosa*) are also prevalent and serve as thatching materials for the Amerindian communities. Small-scale clearing of forested areas for subsistence farming through shifting cultivation methods has been the culture of the Amerindians for many years and is still undertaken.

Forested areas gradually give way to extensive savannas. The savanna is a rolling grassland scattered with shrubs and isolated trees. Unlike the soils found in the forested areas, soils in the savannas are generally nutrient poor. Plants that are prevalent here are those that are specially adapted for drought conditions. They may have long tap roots which will enable them to reach the deep water table, drop their leaves in the dry season to avoid evapotranspiration and/or have underground storage organs to conserve water. Ranching has historically been the dominant human activity in the savannas, with the wide use of fire as a management tool, although in recent years ranching has subsided.

With regard specifically to the fauna of the North Rupununi, it has been estimated that this region supports populations of over 65% of the species of wildlife found in Guyana (Iwokrama and NRDDB, 1998) and it is a known fact that Amerindian communities have coexisted with such wildlife for thousands of years (Forte, 1996). The North Rupununi is home to many species of endangered animals and including those that have come to be known as the ‘Giants of El Dorado’. These include the harpy eagle (*Harpia harpyja*), capybara (*Hydrochaeris hydrochaeris*), jaguar (*Panthera onca*) and giant anteater (*Myrmecophaga tridactyla*). The Rupununi, Rewa, and Essequibo River systems are home to over 450 species of fish, including the arapaima (*Arapaima spp*), the world’s largest freshwater fish. Interestingly, comparable wetlands in South America such as the Varzéa of Mamiraua and the Pantanal wetlands, indicate records of only 400 and 200 species of fish respectively. In addition, there are healthy populations of internationally endangered species such as the giant river turtle (*Podocnemis expansa*), black caiman (*Melanosuchus niger*), and giant river otters (*Pteronura brasiliensis*).

Overall, it is important to recognize and appreciate the functions of the many unique ecosystems that are part of the North Rupununi both individually and as one large interconnected system, which is ultimately responsible for the health and productivity of all the biodiversity found within it.

The People

The North Rupununi Wetlands and the surrounding region is the traditional home of the Makushi people. Although the Makushi are still the primary ethnic group in the area, many communities contain a mixture of other indigenous groups and immigrants from the more populated coast. The primary livelihood activities in the area are subsistence farming and fishing, with some amount of hunting and gathering, trapping, brick making, and cattle ranching. The main local crop is cassava (*Manihot esculenta*), of which several varieties are grown to produce *farine* (roasted cassava grains), cassava bread, tapioca, and various beverages. There is also some local commercial exploitation of wildlife for the meat and pet trades. Wildlife represents a major local food source in the North Rupununi. Mammals and fish, in particular, provide the majority of the protein intake for villagers (Watkins et al., 1999). According to a study by the Makushi Research Unit (Forte, 1996) over 100 species of fish are eaten by the Makushi. As such, fishing is an extremely important subsistence activity. Aside from subsistence and economic value, the North Rupununi Wetlands also feature prominently in indigenous culture and folklore, and have significant aesthetic value, serving as a primary place of recreation for local residents.

The residents of the North Rupununi are distributed among twenty primary communities, consisting of approximately 9000 people. Although sixteen of these communities have legal title to some of their traditional lands, all of the communities currently practice customary user rights to their surrounding land and resources. The villages are represented by elected Toshao, or Captains. These leaders came together in 1996 to establish the North Rupununi District Development Board (NRDDB), a regional, community-based NGO, which currently acts as the coordinating body for conservation and development initiatives in the area.

Challenges

The extreme remoteness and wilderness of the North Rupununi and the isolation of its people make it vulnerable to illegal and poorly managed resource extraction, pressure to convert natural habitats, and climate change impacts, with limited oversight and support from statutory agencies, situated hundreds of miles away on the coast. Direct threats include the growing global demand for commodities and processed products such as gold, cocaine, palm oil, soy, rice, meat, aluminium, and petroleum. Other threats are highlighted in a recent study on the interaction between deforestation, fire and drought in the Amazon potentially leading to losses of carbon storage, and changes in regional precipitation patterns and river discharge (Davidson et al. 2012). The same study concludes that the increase in droughts associated with climate change is likely to worsen changes in these precipitation patterns, thus further exacerbating the direct impacts of land-use change on remaining wilderness areas.

Small-scale and large-scale mining activities, oil prospection and extraction, dam building, and large-scale agriculture all have impacts on complex and fragile tropical environments. For example, the impact of the mining sector on the environment is profound and durable. It is responsible for the clearing of forests and the pollution of rivers and soil. The dispersion of chemicals in water and air contaminates the food chain and has an impact on biodiversity. Gold mining is an increasing presence in the region with concessions to major international corporations having recently been issued in the headwaters of the Rupununi and Rewa rivers (Guyana Goldstrike, n.d.)

With a population density of fewer than three people per square kilometre and largely concentrated in the town of Lethem on the Brazilian border, the North Rupununi is amongst one of the least populated areas on Earth. Despite the existence of legally recognized Indigenous lands, this remote region is attractive to illegal activities such as drug trafficking and gold mining, as has been documented in nearby regions (Phillips 2011). Its strategic location and troubled history may also raise questions of national security (Butler 2012). Consequently, issues with regards to territorial sovereignty through foreign owned and/or funded large-scale infrastructure projects such as road-building, dams, and mega-farms, with associated peopling, including on Indigenous lands (MacDonald, 2014; 2016).

All tropical ecosystems are sensitive to land-use and climatic change, but wetlands are particularly sensitive. It is therefore imperative to establish a baseline for the current biophysical condition of the North Rupununi Wetlands, so as to inform appropriate and sustainable development strategies while monitoring the impacts of current and emerging developments in the region.

Research on the Rupununi Portal to-date

Much has been speculated about the ecological significance of the 'Rupununi Portal'. Lowe-McConnell (1964) provides one of the first comprehensive list of fish species present in the region. More recent studies have gone beyond a straightforward identification of fish species, to focus on understanding their genetic diversity (de Souza, 2012). These various studies have identified over 450 distinct fish species in the region, placing the North Rupununi Wetlands as one of the most biodiverse aquatic ecosystems in the world, as far as fish are concerned. These studies have also provided proof of a significant overlap in fish species composition between the rivers and water bodies of the Amazonian and Essequibo basins. However, all of these studies are rather vague with regards to the exact location and dynamics of the hydrological connectivity. For example, Figure 4 is an extract from a map published in Lowe-McConnell (1964) indicating a number of creeks from the Ireng and Rupununi rivers converging towards 'Lake Amuku' – the site of the 'Rupununi Portal'.

In-text descriptions within various publications also limit themselves to one-sentence statements:

"As the Rupununi savannas are extensively flooded in the rainy season the Amazon and Essequibo drainage systems are here in contact in wet years, meeting in the vast flooded plain known as Lake Amuku." (Lowe-McConnell, 1964, P. 105)

"Pirara head, which is the exact site of the Takutu connection to the Rupununi portal" (de Souza, p.46).

"During this research, it was possible to identify and confirm that the Bononi Creek represents the link between the Essequibo watershed and the Amazon watershed"(Ingwall-King, 2013, p.204)

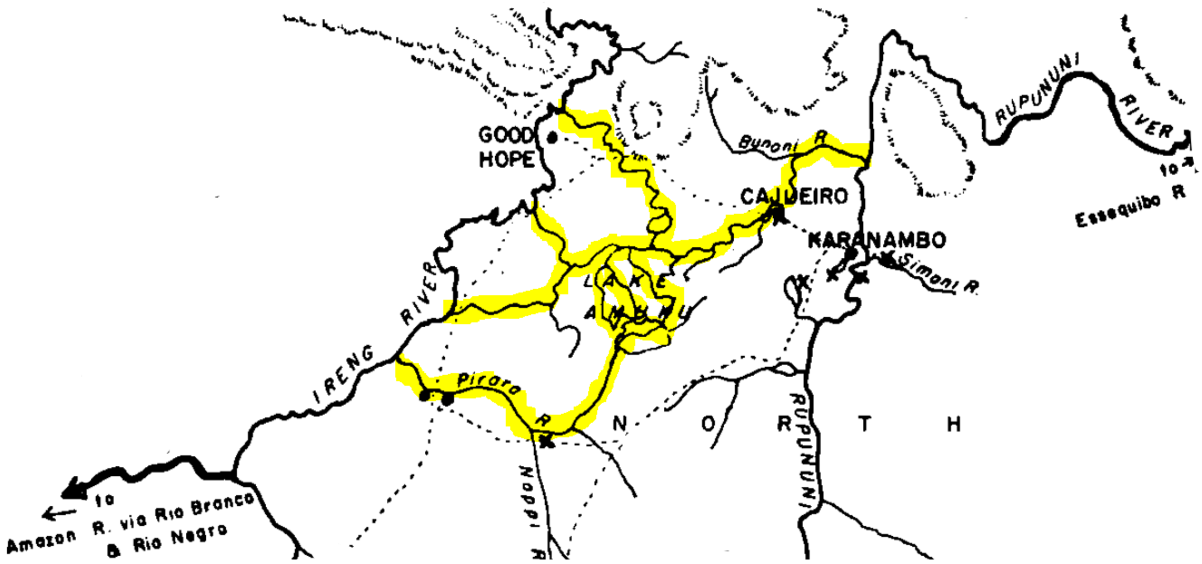

Figure 4: Map extract from Lowe-McConnell (1964) indicating at least five distinct hydrological connections between the Ireng and Rupununi rivers (our highlighting in yellow)

Since there is an increasing number of diverse threats that may affect the connectivity and dynamics of the hydrological links between the Ireng and Rupununi rivers, there is, therefore, an urgent need to precisely map and characterise the dynamic nature of the hydrological connectivity. It is also important to study actual species movement across the region, so as to identify where and when these points of connectivity become important for which species.

Aims, methodology, and timeline of our research

The primary aim of this project was to locate and map the hydrological links between the Amazon and Essequibo basins and collect proof of species movement across the basins. Scientific evidence of these links would help support appropriate development and conservation in the region while at the same time provide a new insight into South American aquatic biogeography.

The project used an innovative blend of community-based participatory video and environmental/biodiversity monitoring, high-resolution drone mapping, satellite image analysis, low-cost species tracking, and ground-based hydro-ecological and topographical surveys. The methodology for this research project is divided into 2 subcomponents: detailed ethnographic research with community members; and geographical, hydrological and species surveys. The following provides some more details on these two subcomponents.

Ethnographic research

This involved focus groups and interviews with local community members within Yupukari, Quatata, and Marikanata – key villages surrounding the Rupununi Portal region. The aim of the ethnographic research was to ask local community members about traditional knowledge with regards to the perceived locations of the link between the Amazon and Essequibo basins, characterise the species thought to move across the link, record any myths or stories associated with the link and/or the species, and compile a range of current and emerging threats which may disrupt the link. Participatory video was the main technique used to record the interviews. This enabled us to edit the responses and then screen them back to participants and the wider community, so as to elicit further discussions and responses. In line with our previous research on social memory, we also used participatory video as a form of permanently recording traditional knowledge for future safekeeping and to be used as an asset by the communities themselves. In addition, we also aimed to produce a short video for wider dissemination representing the views of the Indigenous community.

A free, prior and informed consent process was undertaken before the focus groups and interviews, and the resulting video material was then shown to the communities so as to gain feedback on content. Community members were also able to decide which content could be shown externally and what additional material would need to be collected so that their views were appropriately represented. Only once approval was gained for the final audio-visual product was it showcased outside of the communities.

The actual interviews were carried out by local Indigenous researchers, led by Felix Holden and Grace Albert. In other words, not only were the communities able to represent their perspective, but the direction and depth of ethnographic research were primarily determined by the local indigenous researchers in order to gauge suitability and to pitch culturally appropriate questions. The primary purpose of non-Indigenous researchers within the team was to build capacity within the Indigenous researchers both in terms of interviewing techniques and in using audiovisual recording.

Having achieved the primary objective of disseminating community perspectives both within the communities and outside, the audio interviews are now being analysed for academic publications in collaboration with the Indigenous researchers and with Dr. Deirdre Jafferally – the project manager and senior researcher. Any academic outputs will include the names of the Indigenous researcher and Dr. Jafferally.

Geographical and hydrological surveys

The aim of this component of the research was to map the hydrological connection of the Amazon and Essequibo basins. This first involved an analysis of remotely sensed radar imagery, followed by drone surveys, high precision GPS ground truthing, and hydrological surveys.

Radar image analysis

A challenge of using remotely sensed satellite imagery for exploring flooding regimes within tropical contexts is that the extensive cloud cover during the wet season obscures what is going on at ground level. However, radar imagery is able to penetrate cloud cover, and since 2014, researchers have been able to freely download imagery taken by the European Space Agency’s Sentinel-1 Synthetic Aperture Radar. Coverage of the Rupununi region is available from late 2015, but the effects of a severe El Nino during the 2015 and 2016 years meant that the North Rupununi Wetlands only experienced significant flooding in 2017, when the El Nino abated. Thus radar image analysis from Sentinel-1 was carried out only for images taken in 2017.

Drone surveys

Drones enable real-time, aerial photographs to be taken. The purpose of our drone surveys was to produce a high-resolution three-dimensional map of elevation, water bodies, vegetation cover, and roads of the watershed divide. This allowed us to identify the key areas where the watersheds allow hydrological connections, and therefore, species movement and exchange, and the habitats through which the species moved. This involved pre-programming survey missions on drone software which then allowed the drone to autonomously fly a series of transects. Communities were fully informed of the drone operation and demonstrations took place within villages so that they were aware of drone operation and purpose. An intensive training programme was also carried out so that the Indigenous researchers could co-design survey missions and operate the drone.

Two different drone technologies were used: a quadcopter (Figure 5) and a fixed wing (Figure 6). The advantages of a quadcopter are that it is cheaper to purchase, smaller to carry (fits in a backpack), and takes off and lands vertically (thus avoiding the need for an extensive and unobstructed runway). However, initial trials with a quadcopter were unsatisfactory as only very small areas could be surveyed as a result of its limited range and battery capacity. Thus, a more advanced fixed-wing drone was purchased which allowed the surveying of areas one orders of magnitude greater.

Figure 5: Felix Holden launching the quadcopter drone.

Figure 6: Toshao Russian Dorrick helping to prepare our fixed-wing drone for a survey mission.

The drone surveys followed strict safety procedures. On the 27th of February 2017, the Guyana Civil Aviation Authority (GCAA) issued a directive stating that no person shall operate a drone above the weight of 7kg in Guyana's airspace without first having received written permission from the GCAA. Although both our quadcopter and fixed-wing drones weighed less than 7 kg, we applied to the GCAA anyway in writing for approval. A detailed, 40-page operations manual was produced (permission was granted to the GCAA to share with other drone operators as a template) in preparation for the missions and included pre-flight risk assessments and checks.

Figure 7 shows a map of the drone survey mission areas that were planned for February 2018 to be flown by the fixed-wing drone. Each pink polygon would enable areas of up to 25 km^2 to be surveyed at a time, producing pictures of a 10 cm resolution. This was by far the biggest gamble of the whole research project. We knew that lots of things can go wrong: technical failure; rain showers; high winds; and human error. Ideally, we would have gone out into the Rupununi with at least two fixed-wing drones, but funding limitations meant that only one was available to us.

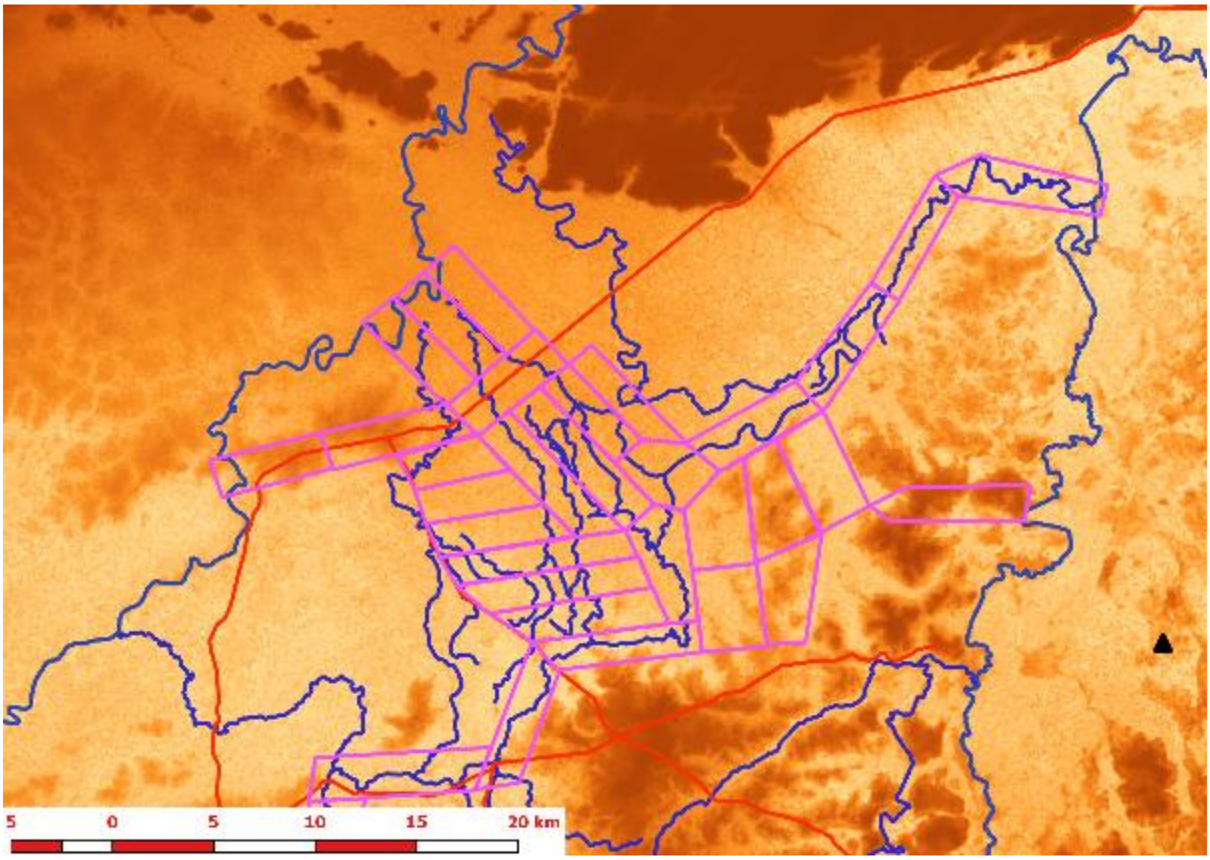

Figure 7: Drone survey mission areas (in pink) planned for February 2018.

Real-Time Kinematic surveys

Real-Time Kinematic (RTK) positioning is a satellite navigation technique used to enhance the precision of position data derived from satellite-based positioning systems (global navigation satellite systems, GNSS) such as the US Global Positioning System (GPS). RTK surveys involve establishing a ‘base’ unit at a fixed point (usually a point of higher elevation - see Figure 8). A second unit, the ‘rover’, is then used to carry out the survey. The rover measures its position relative to the base unit to an accuracy of several centimetres. This allowed us to correct the elevation maps produced by the drone surveys and to have instant high precision data on the elevation of areas that we were surveying, thus allowing us to develop a conceptual model of hydrological connectivity as we were working on the ground.

Figure 8: The RTK base station positioned at a point of high elevation overlooking the Rupununi Portal region in February 2018, at the height of the dry season. The same view during the wet season would show a transformed wetland landscape.

Species surveys

The species surveys involved two components: regular monitoring of selected sites by local Indigenous researchers, and the experimental tagging of black caiman to monitor their movement near the watershed divide.

Felix Holden, together with several Indigenous research assistants, undertook the following surveys:

- Fish surveys in five strategically located areas within the Rupununi-Ireng watershed divide. A variety of fishing techniques, including seine nets, were used to catch species moving across the link(s) while water was present. Recordings of fish species, their number, and size were made. The caught fish were consumed by the families of the researcher and the assistant unless the fish was a protected species, which then require for it to be released.

- Wildlife observations within the same strategically located areas, including tracks and scats.

- Water height and flow direction within the same strategically located areas.

- Interviews with community members encountered within these areas in order to supplement the fish and wildlife observations.

A final component of the research was to explore whether it would be possible to tag species observed living within the watershed divide zones with trackers. We initially explored the possibility of using GPS trackers, but these proved to be too expensive. We, therefore, focused on developing cutting-edge tracking technologies using readily available electronic components now being used to track parcels in warehouses. Our aim was to see if we could develop a tracking unit that was low cost (less than £10 each), could emit signals for over a year, and would be resilient to the environmental conditions (waterproof and shock resistant).

Research permits and timeline

As outlined in our original proposal, a permit from Guyana's Environmental Protection Agency (EPA) would be needed as soon as notification of project funding was received (an EPA permit can take up to 3 months to be given, but further delays can emerge). Notification of funding from the Woodspring Trust was received on 15 May 2017. This enabled Dr. Jafferally to immediately initiate a permission request from various parties, requiring first a meeting with the Indigenous leadership at an NRDDB to confirm the project. Russian Dorrick, Toshao of Yupukari Village, issued a letter permitting the team to carry out research within the communities of Yupukari, Marikanata, Quatata Kaicumbay and Fly Hill, and the surrounding region. This then allowed us to submit a research permit request to the Ministry of Indigenous Peoples' Affairs (MoIPA). Having achieved a permit from MoIPA, the EPA could complete processing the submitted research permit request. While we were awaiting notification of the EPA permit, the team carried out an intensive period of community and stakeholder engagement. While Dr. Jafferally was leading on the permits and engagement, Dr. Berardi and Dr. Simpson were monitoring the situation through the analysis of Sentinel-1 radar imagery during the peak wet season (May to July), and preliminary field visit from the 30th August to 11th September 2017.

A research permit from the EPA was eventually issued for the period 29th September 2017 to 20th February 2018. This enabled the initiation of regular monitoring of selected sites by local Indigenous researchers from October 2017 onwards, and an intensive period of field research from the 10th to 20th February 2018, followed by a series of community and stakeholder engagement events.

A significant outcome of this initial period of consultation, engagement, and research aided Dr. Jafferally's participation in a series of stakeholder meetings involving a consortium led by the North Rupununi District Development Board, and involving conservation organisations (e.g. WWF, Conservation International, Iwokrama) and research institutions (e.g. University of Guyana). This resulted in a letter being submitted to MoIPA requesting for a moratorium on further high-impact development within the North Rupununi Wetlands (see Appendix).

Preliminary Results

Ethnographic study

Eleven community members from Yupukari, Quatata, and Marakanata volunteered to be interviewed regarding traditional knowledge of the hydrological connection(s), myths, stories, current uses and concerns with regards to the 'Rupununi Portal' region. Over two hours of recorded interviews were edited into a first video of 24 minutes which was screened in Yupukari for feedback in February 2018. Two additional interviews were then carried out to produce a 30-minute video which will be provided exclusively to the community/NRDDB to use as they wish. A significantly shorter video and animation will be produced for public release.

Figure 9: screenshot of Delene Lawrence, manager of Caiman House, taken from her videoed interview.

The interviews showcase a rich social memory of the region. Individuals recounted stories of dangerous spirits present in several water bodies within the Rupununi Portal region, which would result in individuals being attacked, disappearing or falling ill if these areas were visited at the wrong time or certain practices were not carried out. Stories also abounded with regards to colonial-era fortifications and water transport links, where military and commercial navigation involved taking advantage of hydrological links between the Rupununi River, the flooded savanna, and the Ireng River. Two main water transportation routes were described (Figure 10). The least significant was a northerly route following the entirety of Bonuni Creek, whose headwaters are separated by only a few hundred metres of flat ground from the Ireng River. This route was used to connect with the missions and communities in the Pakaraima mountains which form the headwaters of the Ireng. The more significant route was identified to the south, which involved navigating up a short stretch off the Kwatata River (a tributary of the Rupununi), then portage of the boats in to Amuku Lake, followed by another short stretch of portage from Amuku Lake to Pirara Creek, which then connected to the Ireng River and thus access to Lethem – the border outpost.

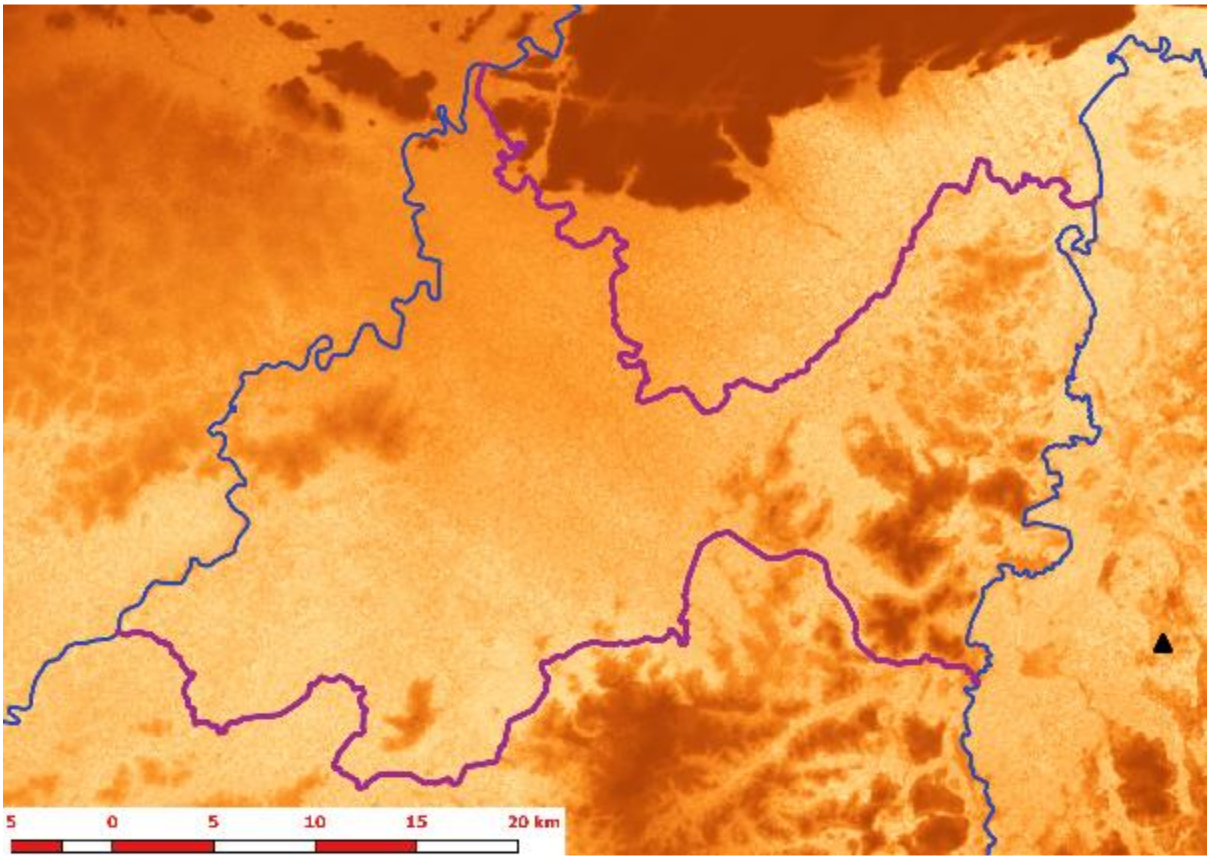

Figure 10: hydrological transportation links (in purple) between the Rupununi and Ireng rivers. The northern link is almost entirely along the Bonuni Creek, while the southern link involves a short stretch up Kwatata Creek, a tributary of the Rupununi River, and then portage into Amuku Lake, followed by a second portage from Amuku Lake into the Pirara Creek.

Individuals recounted having come across very large skulls and skeletons of arapaima, giant river turtle and other aquatic species within the waterbodies straddling the Rupununi Portal region, indicating that large specimens were reaching these areas and becoming stranded as the water receded. They also highlighted the importance of this region as a spawning area for many fish species, with waves of different species taking turns to 'march' up the Bonuni and Pirara creeks as floodwaters reached the Rupununi Portal. As floodwaters receded, this vast wetland region would leave behind ponds teeming with fishes that were increasingly concentrated into smaller water bodies, thus providing a readily accessible and bountiful source of fish for both human and wildlife consumption. However, these ponds weren't without dangers, with individuals recounting how friends and family were attacked, and even killed, by black caiman and anaconda. Protection from attack often involved undertaking rituals or wearing charms.

Interviews progressed onto the current challenges facing the communities. All respondents highlighted their concerns with regards to recent appropriation of their traditional lands by 'mega farm' projects, which fenced off access to customary fishing and hunting territory, and converted vast areas of natural savanna and wetland habitat into bare ground for intensive cultivation. Fears were raised with regards to impact on wildlife and human health from the use of artificial pesticides and fertilisers, either directly, as a result of ingestion of contaminated water, or indirectly, from accumulation of toxins within the fish consumed. Worries were also raised with regards to the impact on ecotourism as dikes and drainage channels to control floodwaters within the intensively cultivated fields would reduce the area available for fish spawning, and the wildlife that depended on these highly productive regions. A direct appeal was made to decision-makers and leaders to manage development in the region in a way which is sustainable for both communities and wildlife.

Radar Image analysis

Although weather forecasters had indicated that the El Niño phase determining severe drought in the region had receded, the months of April, May, and June in 2017 resulted in very limited rainfall and scant surface flooding. However, in the first weeks of July, heavy rains in the headwaters of the Ireng and Takutu and Rupununi Rivers resulted in an extreme, and short-lived, flash flood. This resulted in the extensive flooding of Lethem, and significant damage to the Lethem-Georgetown road, as floodwaters, swept from the Ireng and over the road, submerging and destroying significant parts of the road. The flooding sequence was captured in the Sentinel-1 radar image analysis shown in figures 11 to 15 below. Highlights of what each image conveys are described in the captions.

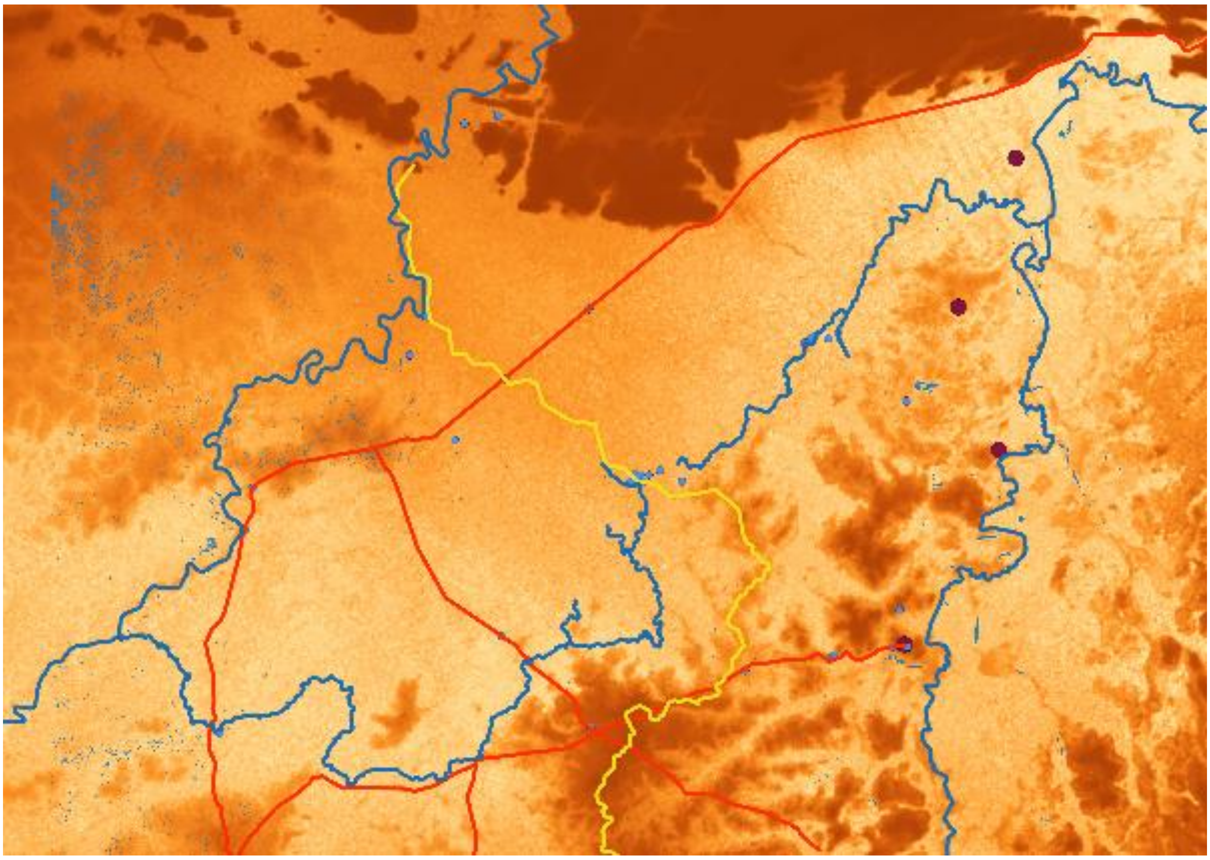

Fig 11: Analysis of Sentinel-1 radar image captured on June 21st, 2017. In a good wet season, by this time, significant surface water should be present alongside the Rupununi and Ireng rivers, and the Bonuni and Pirara creeks. However, no standing water is detected. To note that the analysis does indicate standing water on dire elevations to the top left-hand side of the image. However, water and bare earth have a similar 'backscatter' effect on the radar signal and is usually corrected by overlaying an elevation 'mask' on the analysis. However, this was not carried out in this case as this 'error' conveys useful information – indicating that rainfall in the region was so limited until this date that insufficient moisture was present for promoting grass regrowth on bare areas of earth.

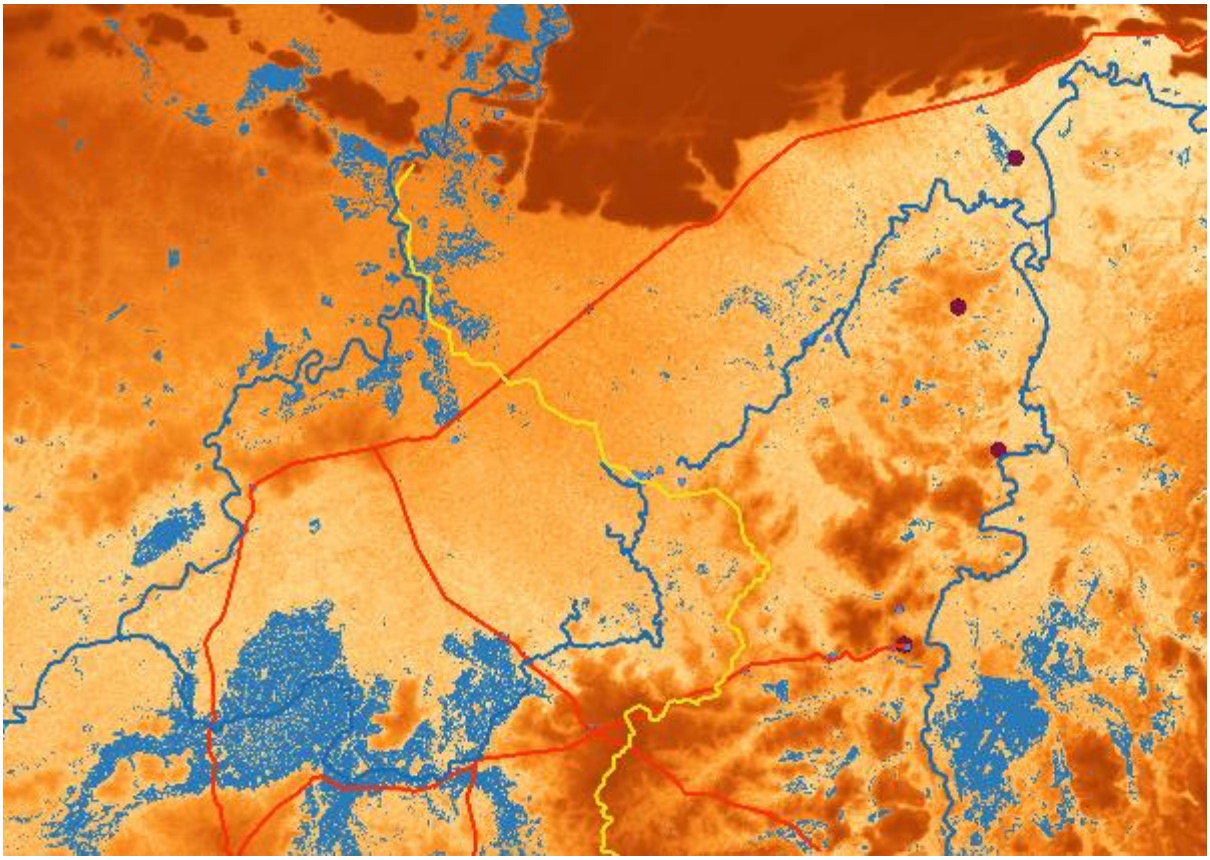

Figure 12: Analysis of Sentinel-1 radar image captured on 3rd July 2017. Suddenly, the picture is completely different – significant rainfall in the region leading up to 3rd July shows an active flooding sequence occurring in this image. The lower parts of the Pirara Creek catchment are being subject to extensive flooding. Just as significant, one can see the upper parts of the Ireng River portrayed in this image breaking its banks, and waves of floodwaters rushing south and east towards the Lethem-Georgetown road.

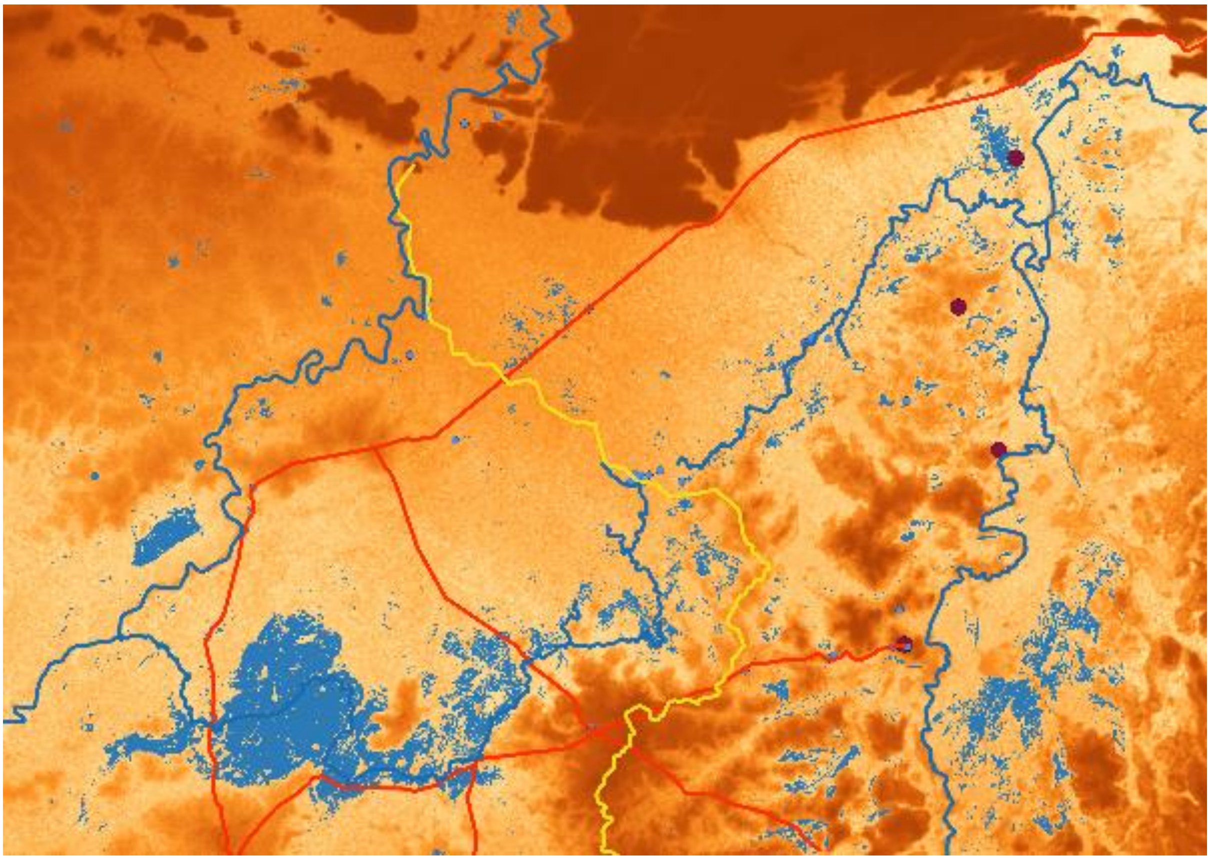

Figure 13: Analysis of Sentinel-1 radar image captured on July 21st 2017. Floodwaters have now mostly swept away from the Ireng River and the Lethem-Georgetown road, although the image is showing that the road is continuing to act as a barrier to drainage. Significant levels of floodwater are still present in the lower Pirara Creek catchment – an excellent outcome for spawning fish. All along the Pirara and Bonuni creek, one can detect areas of flooding. This might actually be an underestimate of flooding extent, as the shallow floodwaters may not have covered the emerging grasses and reeds, thus affecting the amount of backscatter that would indicate standing water within a radar image. The presence of floodwaters just below emerging vegetation was confirmed once our research team was permitted to initiate fieldwork in October 2017.

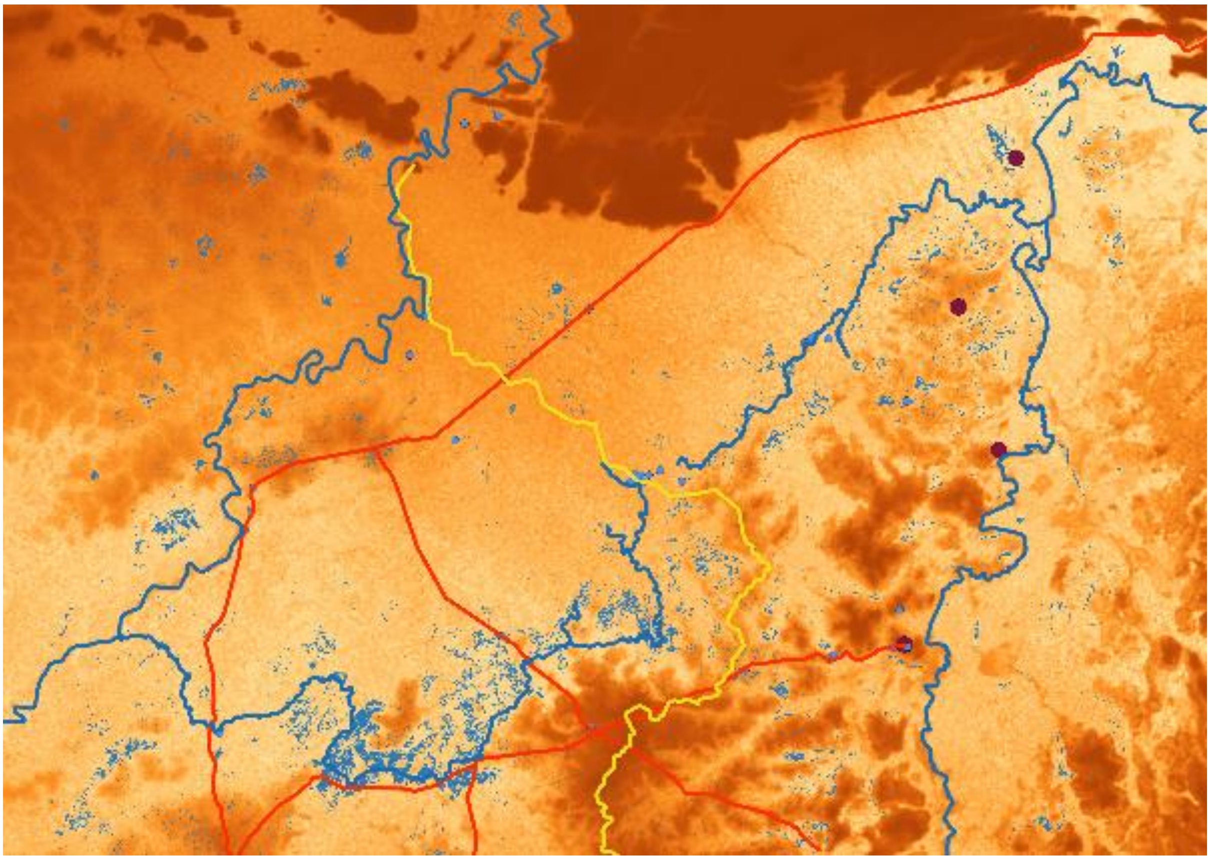

Figure 14: Analysis of Sentinel-1 radar image captured on 8th of August 2017. By this date the major floodwaters affecting the lower parts of the Pirara Creek catchment had subsided, although standing water is still evident along the Pirara and Bonuni creeks. To note that the ‘backscatter error’, mistaking bare earth for water, is now beginning to emerge on the higher elevations along the Lethem-Georgetown road, possibly indicating that the high rainfall may have aggravated the levels of soil erosion in the areas, resulting in further exposure of bare ground.

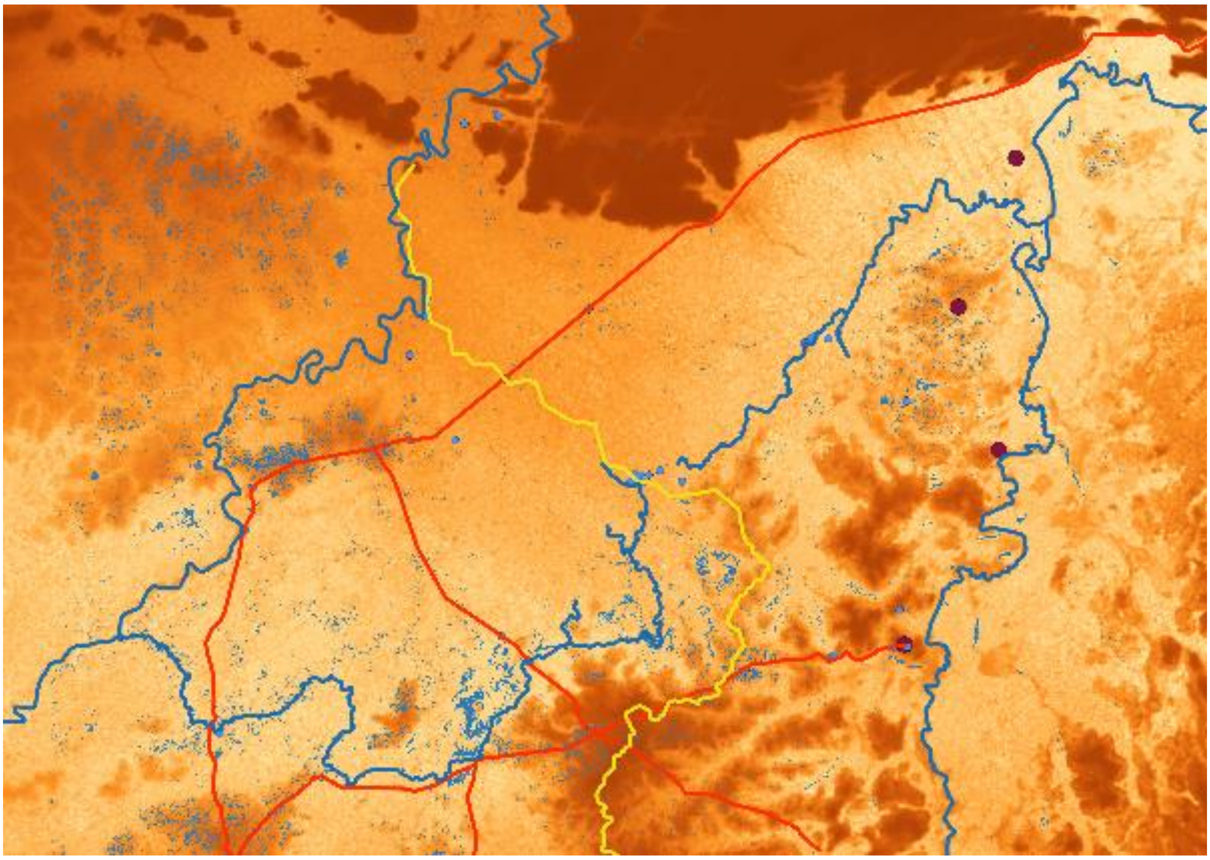

Figure 15: Analysis of Sentinel-1 radar image captured on 20th of August 2017. Major 'backscatter' error can now be seen on the higher elevations. However, the lower elevations around Pirara Creek still show extensive surface water, while significantly less surface water seems to be present along the Bonuni catchment.

Drone survey and RTK analysis

Out of the 30 drone survey missions planned, only seven missions were actually flown, and out of these, only four provided imagery. We were challenged by the weather (high winds and rain), difficulties in finding suitable take-off and landing sites, technical glitches, competing tasks and ultimately, mechanical failure in the penultimate day of fieldwork. However, we prioritised our surveys to focus on the most important areas first, and the imagery that we did get provided some significant insights on the vegetation distribution and hydrology of the Rupununi Portal region. Figure 16 is an example of a drone image taken by the fixed-wing, showcasing the incredible habitat complexity apparent within the region's water bodies. Each colour zone represents a distinct habitat type composed of a unique assemblage of plant species.

Figure 16: Single image of a waterbody within the North Rupununi Wetlands taken by the fixed-wing drone in the middle of the dry season in February 2018.

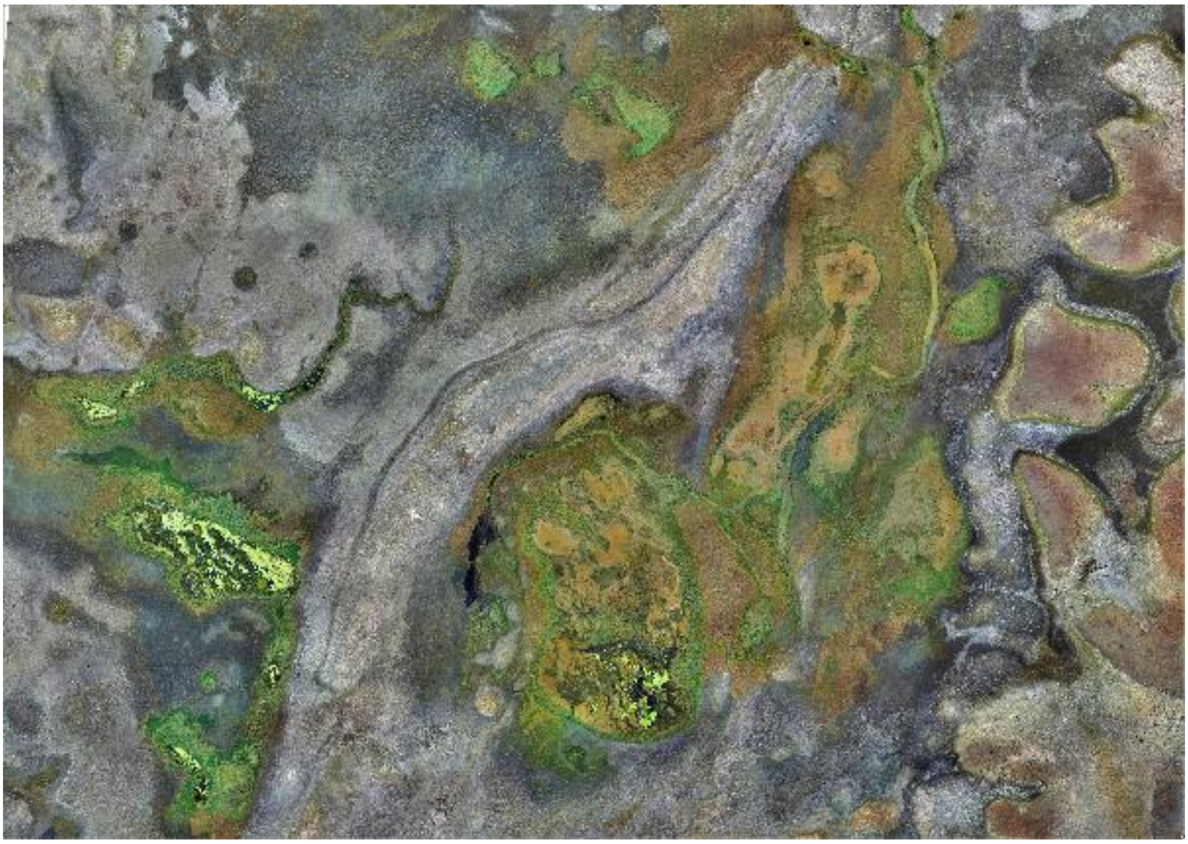

Figure 17: Composite picture of the Rupununi Portal region made from stitching together over one hundred individual images from one of the fixed-wing drone surveys.

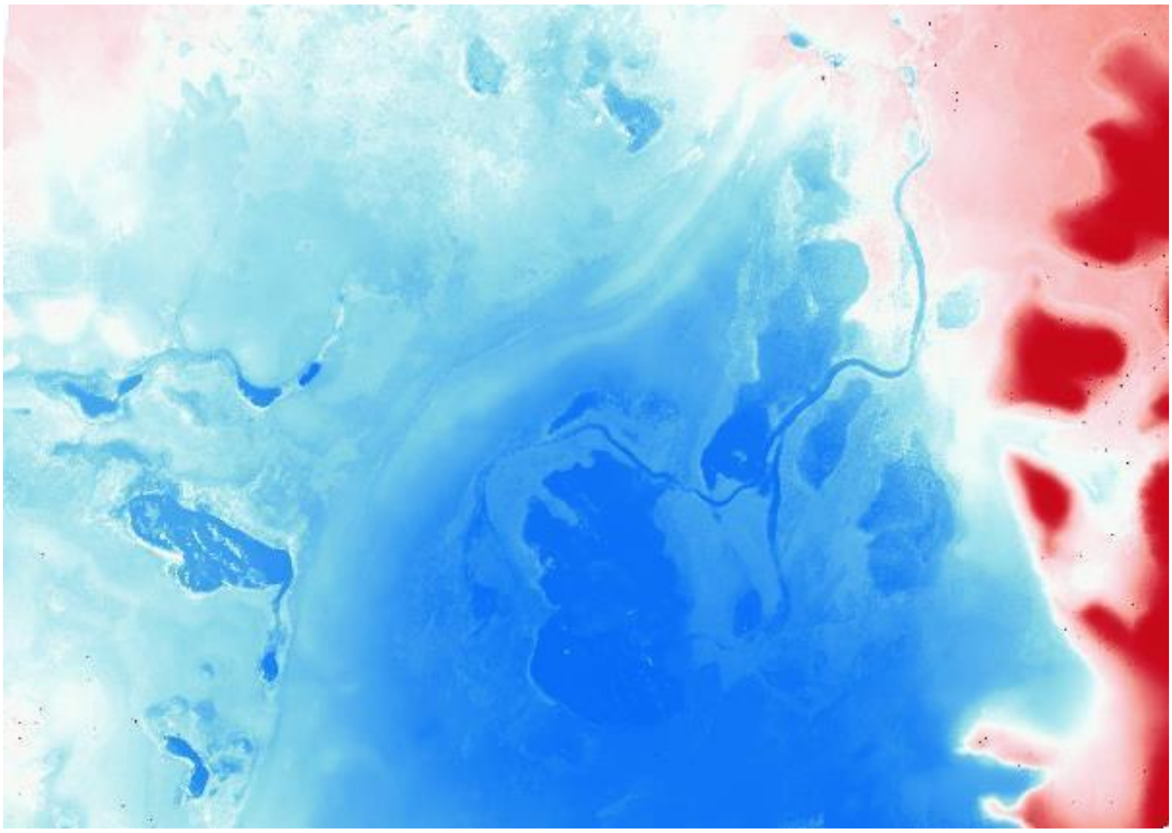

Figure 18: Digital Surface Model of the region represented in Figure 17. Red colour shows higher elevations while blue colour represents the lower elevations.

Figure 18 illustrates the most significant result of the drone survey missions – the discovery that there are actually at least two distinct hydrological networks in operation. In the dry season, surface water flows through channels situated at the lowest points of the catchment (the small meandering blue line to the right in Figure 18). During the wet season, however, when all of the lower elevations are covered in surface water, surface drainage occurs through an additional set of channels that are significantly higher than the dry season network (the much straighter pale blue line at the centre of Figure 18). These tend to be created along lines of shortest distance between drainage bottlenecks.

To complement the drone surveys, we traversed the entirety of the Rupununi Portal region collecting GNSS points through a combination of low-resolution handheld devices and, in areas of high interest, through the use of the RTK units. These spatial coordinates, the radar analysis, and expert assessment of eco-hydrological features by Dr. Simpson allowed us to develop a comprehensive conceptual hydrological model of the Rupununi Portal region. We identified three distinct sources of floodwater within the 'Rupununi Portal'. The most disruptive is from the Ireng – usually resulting in damage to the road that links Lethem (on the Brazilian border) to Georgetown (on the Caribbean coast). This is rapidly flowing, shallow water across a large, flat area (Figure 19).

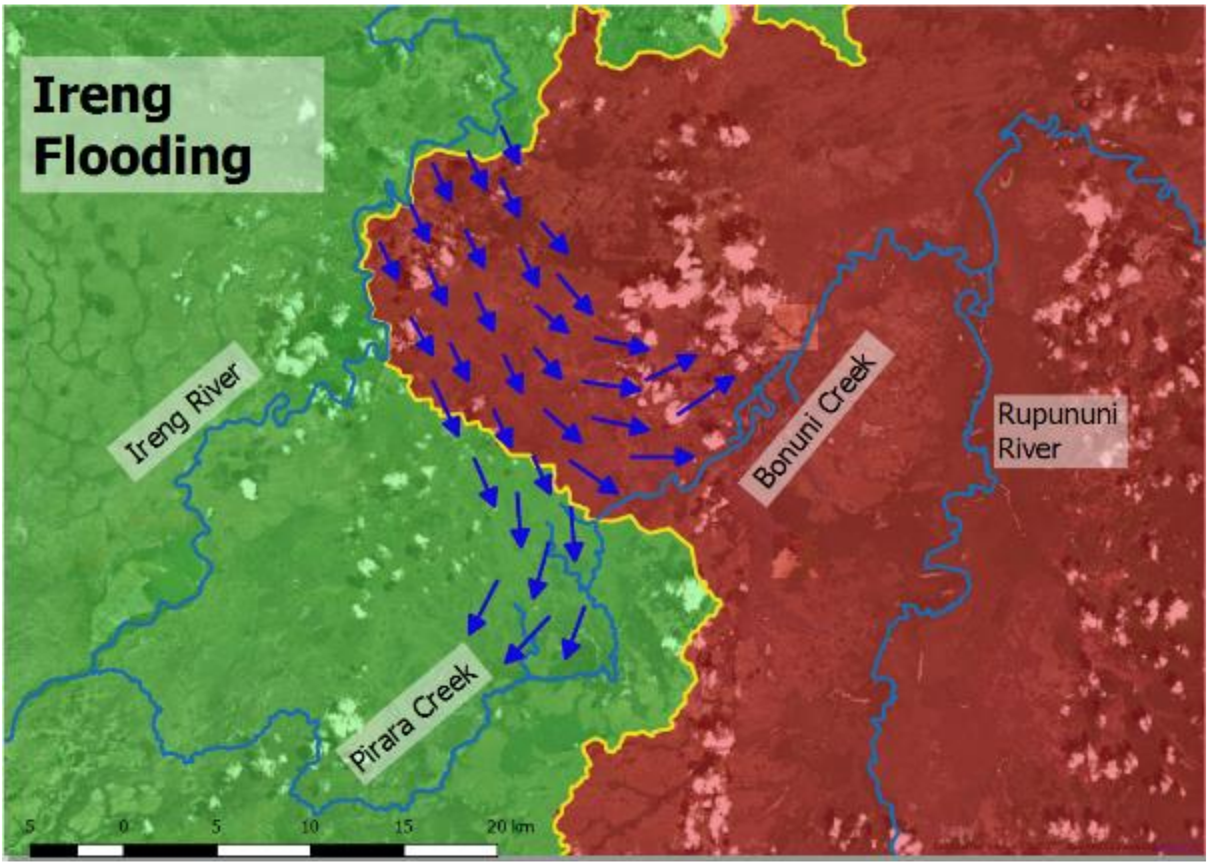

Figure 19: Flooding into the Rupununi Portal region from the Ireng River.

A second source of floodwater is from the Takutu River. Flooding in the Takutu backs-up water in the Pirara Creek, which links to Bonuni Creek on the Rupununi side (Figure 20).

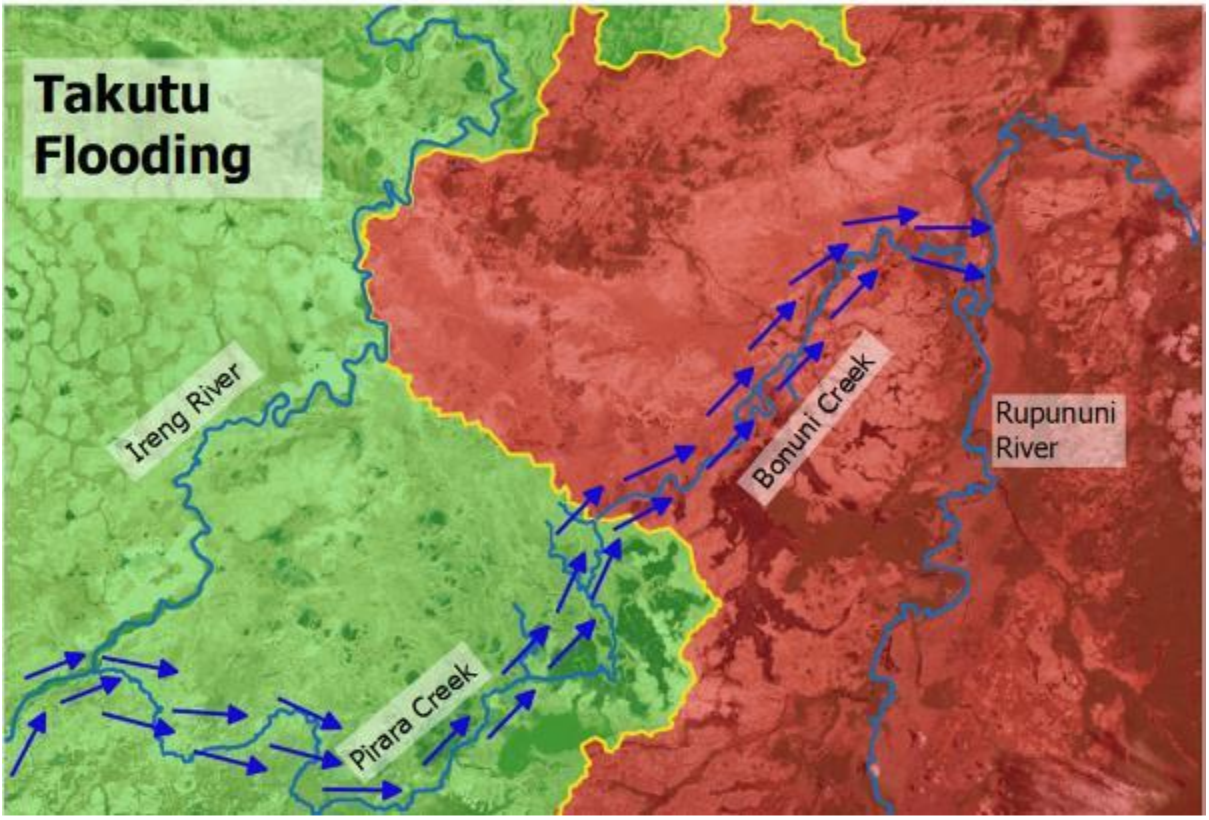

Figure 20: Flooding into the Rupununi Portal region from the Takutu River.

A third source of floodwaters is from the Rupununi River. Flooding in the Rupununi backs-up water in the Bonuni Creek, which links to Pirara Creek on the Ireng side (Figure 21).

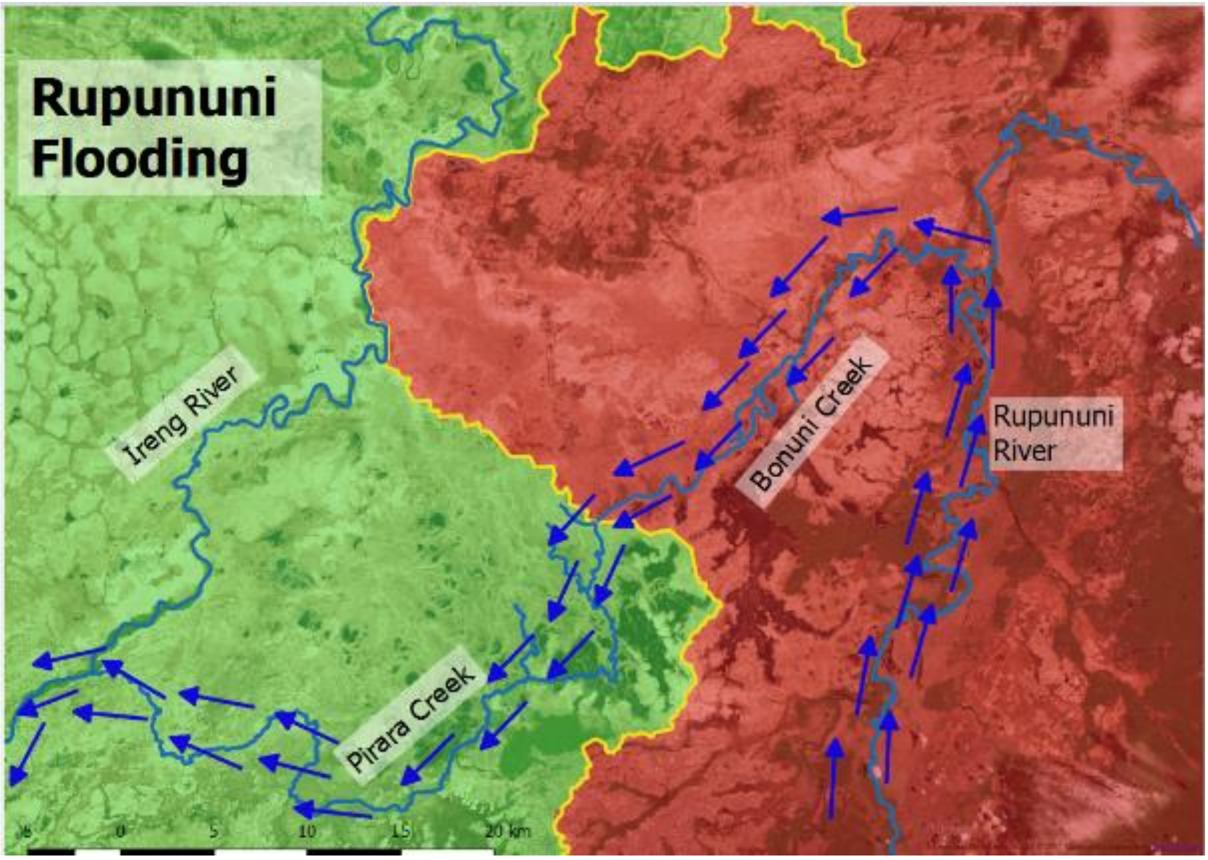

Figure 21: Flooding into the Rupununi Portal region from the Rupununi River.

What we witnessed in the 2017 wet season was a significant volume of water coming down the Takutu River to flood the lower reaches of the Pirara Creek. More 'flashy' flooding was apparent from the Ireng River. These waters very quickly traversed the breadth of the Rupununi Portal region to settle in the upper regions of the Pirara and Bonuni creeks. Weaker flooding from the Rupununi River contributed to the flooding of the lower Bonuni Creek. Of course, waters from all of these three sources influence to drainage patterns, thus reinforcing the effects of flooding from other sources.

Species surveys

Over 400 records were made of species found in five representative waterbodies from October to December 2017 (Figure 22). We are currently analysing the data in order to identify species distribution patterns. In addition, we have made significant progress in developing a low-cost LoRa tracker (Figure 23). A unit is currently being tested in the field to see how it will behave in the tough environmental conditions.

Figure 22: A collage of a representative selection of fish species photographed by Felix Holden and/or his research assistant within one of the five sites monitored.

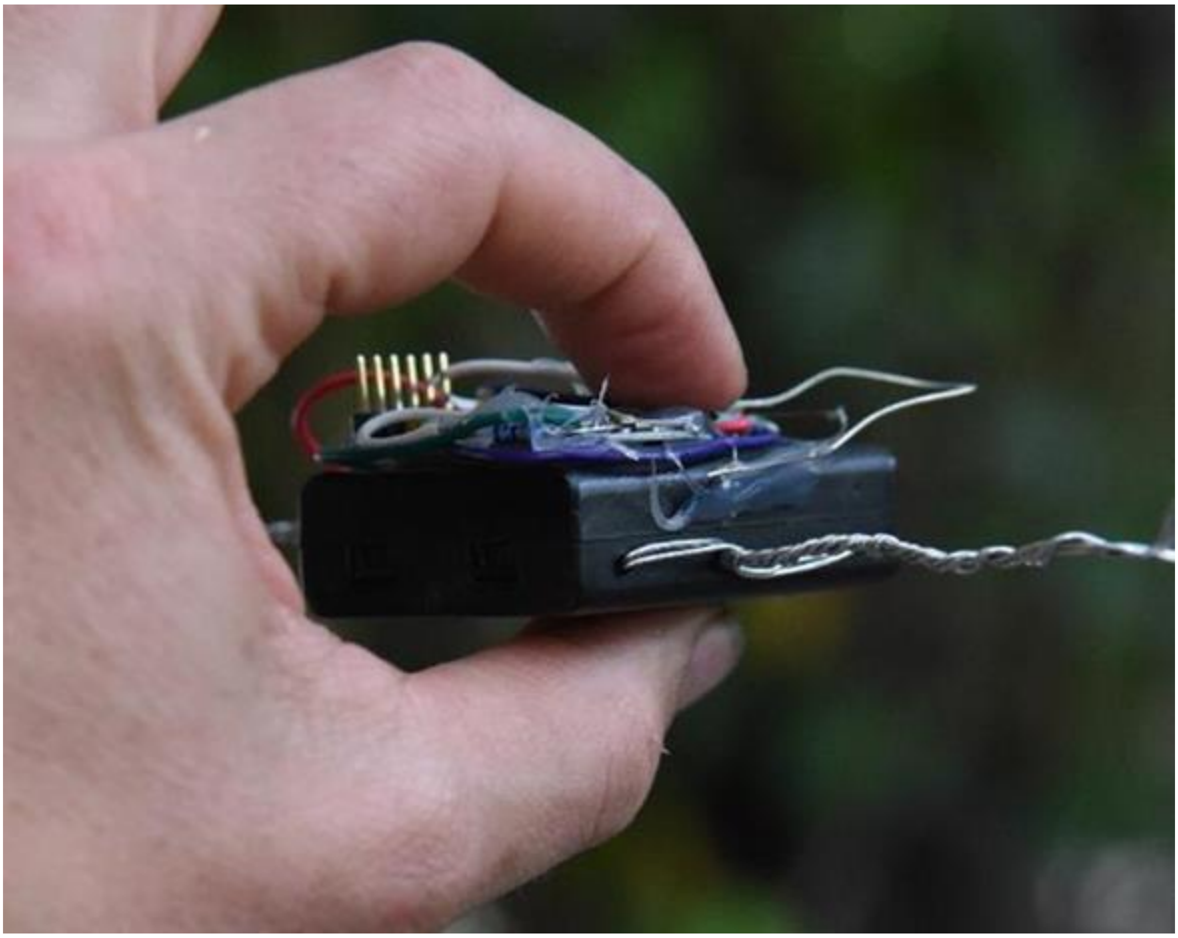

Figure 23: LoRa tracker unit before being encased in maritime epoxy.

Discussion

The headline result of our research to-date is that there is clearly no singular 'neat' hydrological connection between the Ireng and Rupununi rivers, as has been stated by other researchers in previous studies. The Bonuni and Pirara creeks are important hydrological conduits, but what has been completely overlooked in previous studies is the direct overtopping from the Ireng River into the Rupununi Portal. In the 2017 wet season that we studied, this direct overtopping may have been the single most important source of floodwaters for the North Rupununi Wetlands. Flooding from the Pirara and Bonuni creeks did result in the creation of significant wetland areas in the lower parts of these creeks, especially in the Pirara catchment. However, this was not significant enough to greatly influence the extent of flooding on the Rupununi Portal. Our study has conclusively found evidence that overtopping from the Ireng River makes a significant contribution to the floodwaters in the Rupununi Portal. These floodwaters are already being impeded by the Lethem-Georgetown road which impacts the important environmental flows that spread out across the Rupununi Portal. This barrier to flow results in lower volumes of water reaching the Rupununi Portal area, thus affecting the wetland habitat and fish spawning grounds. Through the satellite interpretation exercise and ground-truthing, we have identified and mapped all of the key culverts that currently exist which allow limited flows to pass under the road. Ongoing analysis of the volume of water, during different flood events, and the culvert conveyance capacity will be presented in the final report but it is clear that the limited number of culverts is not allowing sufficient flows, in all locations, to pass the barrier of the road. This is also an issue for road integrity as significant flood volumes result in major damage to road infrastructure disrupting the only road link between Lethem and Georgetown. The last major flood occurred in July 2017 as illustrated in Figure 24. It is therefore imperative that these water flows are not further impeded to maintain the important environmental flows and to protect road transportation in the region. In our final report, we will identify key areas where an extended sequence of culverts should be installed both to promote water flow and prevent road damage.

Figure 24: Flood damage to the Lethem-Georgetown Road in July 2017.

Our preliminary findings also indicate that all low-lying areas within the region have the potential to play an ecological role, especially in support of spawning fishes. During our February fieldwork, a new major agricultural project had been proposed for the lower catchment area of Pirara Creek involving the damming and extensive flooding of one of its major tributaries, Nappi Creek (Figure 25)

Figure 25: A plan for the proposed agricultural centre, showing the extensive area of flooding which will result from the damming of Nappi Creek. Note also the location of the agricultural area (in green and light blue).

Our research shows that the proposed agricultural research station is exactly on the footprint of the July 2017 floods in the lower Pirara catchment (Figure 26). Damming the Nappi Creek, and converting the natural habitat of a significant proportion of Pirara creek into industrial agriculture, will prevent fish from accessing a key spawning area. This is especially important in years, such as 2017, when only part of the North Rupununi Wetlands was flooded.

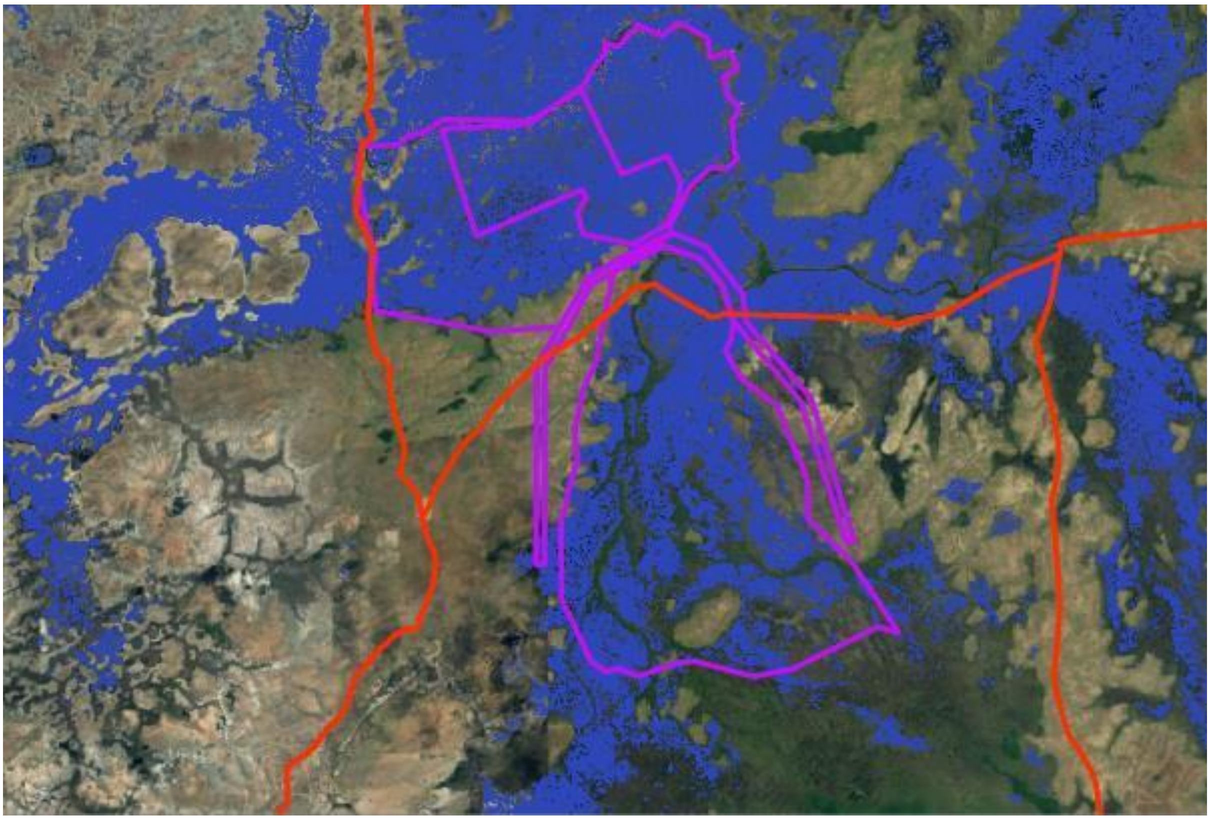

Figure 26: Footprint of the proposed Agricultural Centre and associated reservoir on the 2017 flood extent.

However, all the research that we have been able to achieve is ineffective without an appropriate mechanism to support stakeholders in Guyana in their current efforts to protect the North Rupununi Wetlands. Indications that more and more land within the North Rupununi Wetlands was being allocated for large-scale agricultural development was the catalyst for the NRDDB to form a collation with conservation organizations and research institutions. An advisory team, comprising Dr. Deirdre Jafferally, was put together to support the NRDDB. This enabled WWF-Guyana to come forward to initiate a series of stakeholder meetings, which enabled our own project to re-direct funding originally allocated to stakeholder workshops towards other objectives. The outcome of the first set of meetings was the drafting of a letter to the Ministry of Indigenous People's Affairs (MoIPA), and subsequently, the President of Guyana, for action to protect the North Rupununi Wetlands. A subsequent meeting with the Minister of Environment showed there was a willingness to support action. An outcome of this meeting was a request for a map to show the area of interest. The first point of action was seeking advice from Guyana's Protected Areas Commission (PAC) and their support for the initiative. Second was seeking technical advice from Damian Fernandes, the former Commissioner of the PAC, on possible actions that could be taken. He helped to develop a process of action which included completing the requested map with all possible available land-use data, community consultations to receive guidance and new stakeholder buy-in to the initiative. The completed map was submitted to the Minister of MoIPA along with a new letter (see Appendix) requesting a moratorium on the allocation of new concessions which would allow the NRDDB to further engage with a wider set of stakeholders to discuss management and conservation options. The letter and map have been sent out to relevant government agencies to provide input on proposed activities and potential impacts for not allocating these lands.

Since then the NRDDB has been attempting to secure a meeting with the President to follow up the moratorium request. The advisory group has, in the meantime, been working to provide the NRDDB with up-to-date information (including the outcomes of this project) so as to enable them to act promptly when the opportunity arises so as to emphasise the importance of the landscape and the need for careful management and sensitive development. Damian Fernandes, with WWF assistance, has also put together a presentation including project data that is being strategically presented to stakeholders to improve understanding of how the wetland functions and the kinds of action that would be needed for management. If a moratorium is achieved, organizations such as WWF and the Cobra Collective would be better able to help the NRDDB leverage funding to develop and implement an integrated landscape management plan for the North Rupununi wetlands and its environs.

Next steps

Over the remaining 9 months of this project, we will continue to analyse the video interviews, remote sensing and drone imagery, RTK data, species data and improving LoRa tracking functionality and resilience. We will also embark on a major awareness-raising initiative in collaboration with the NRDDB and WWF. Part of this strategy has been the commissioning of an animation to explain the hydrological dynamics within the Rupununi Portal, and its importance in maintaining the region's high levels of biodiversity. This animation will be co-funded by this project and WWF. We will also publish a series of peer-reviewed papers providing in-depth scientific explanations for the location and dynamics of the Rupununi Portal, including guidance for appropriate development, especially with regards to the road upgrade and proposed mega-farms.

Research to protect the North Rupununi Wetlands is a long-term commitment which members of the Cobra Collective have been pursuing for the last two decades. As such, we will continue fundraising so that we can work on our next research and engagement priorities. The following subsections outline our current strategy.

Water quality monitoring.

Changing land use in the Rupununi Portal area and in the wider catchment, that is the hydrological source areas of floodwater within the Rupununi Portal, has the potential to impact on surface water and groundwater quality. Land use change includes agricultural expansion, reservoir construction, road improvements, logging, and mining. These all have the potential to impact negatively on the flora and fauna of the region and for the local communities that rely on river water and groundwater to directly impact negatively on their drinking water source. To understand the potential impact of changing land use in the region we are proposing to undertake water quality assessments of key surface water inflows to the Rupununi Portal and community groundwater wells. This monitoring will not only identify any current water pollution problems but also provide a baseline for future assessment as land use change occurs. These data can then be used to understand any potential health impacts from a lowering of drinking water quality and/or a reduction in food sources if, for example, fish populations decline.

Hydrological monitoring

The current project has identified the hydrological mechanisms for flooding and water movement across the Rupununi Portal. The next stage is to understand the hydrodynamics in terms of water levels and relate this to the hydrological mechanism model that we have developed. Water level fluctuations are key to allow species movements and, in particular, are a trigger for fish spawning. Relating flood levels in the main rivers to water levels in different areas of the Rupununi Portal can only be accurately understood with the installation of real-time water level monitoring devices. We are proposing the installation of a network of piezometers that measure shallow groundwater levels, and surface water monitoring devices to measure surface and groundwater levels across the region. These devices will provide hourly data of water levels to enable an analysis of flooding patterns in the portal area so they can be related to flooding in the various river systems. Installing a network of piezometers, along a series of transects, allows the peizometric head of water to be determined and therefore the direction of sub-surface flow to be understood. This is important in the Rupununi Portal region as many of the soils are highly permeable which indicates that groundwater and surface waters will meet during flood event periods whilst at low flow periods surface water will disappear underground, flowing downslope and connecting to ponds, lakes, and rivers, but crucially also entering the aquifers that many communities rely on for drinking water. The installation of water level monitoring equipment and the analysis of the data collected will allow us to determine the impacts land use change and climate change will have on the hydro-dynamics of the region.

Drone surveys

Providing high-resolution baseline vegetation and elevation maps of the North Rupununi Wetlands is an essential prerequisite for ecological analysis and environmental impact monitoring and assessment. Many lessons were learnt throughout this project with regards to drone surveys, and we are now in a position where we have identified the appropriate equipment needs and procedures for completing the originally planned 30 survey missions, and even going beyond these. Priority is the purchase of an additional fixed-wing drone so that we will have two units available to us. The major cost of fieldwork is actually getting the personnel into the North Rupununi. Given that the environmental and mechanical challenges are significant, it, therefore, makes sense to have two units available for the survey. Even in the extreme situation where both units do experience mechanical problems, there is a high probability that we would be able to cannibalise functioning parts from one unit and repair the other in order to guarantee a continuation of the survey missions.

Species monitoring and tracking

One thing is to understand the hydrology, and another is to directly assess the impact on species. By the end of this project, we are therefore aiming to have produced a low-cost (sub £10) tracking device which can be mass produced and can be attached to a wide range of keystone species, including the black caiman, giant river turtle, giant anteater, jaguar, and savanna deer. We are in consultation with zoologists in US universities in a potential research collaboration where we provide and maintain the technology and collaboratively undertake the tagging.

Our current design has involved the installation of a series of staggered base stations which would pick up an unlimited number of tracking signals. The problem is that these base stations would require time-consuming regular visits to change batteries and download the data. Ground base stations are also exposed to theft and damage (through, for example, wildfires). Our significant advance in fixed-wing drone deployment has allowed us to incorporate this new technology so as to significantly reduce the number of ground base station. Instead, a receiving antenna will be incorporated into our fixed-wing drone, which will allow a rapid survey of an area without the need for an extensive network of permanent ground-based receiving stations.

Funding and Acknowledgements

This project was made possible through a £26,450 grant from The Woodspring Trust - a UK registered charity offering funding to projects around the world with outstanding potential to achieve long-lasting, positive nature conservation outcomes (http://woodspringtrust.org/). Financial contributions from other sources enabled the purchase of £4,055.98 worth of equipment and training and covered £2,229.10 worth of travel costs. In-kind contributions of time by Dr. Andrea Berardi and Dr. Matthew Simpson were provided, totaling a combined 45 days, which were taken as leave from their full-time jobs in order to support the project.

We are grateful to the 'Indigenous Knowledge' Darwin Project, which has allowed the sharing of logistical facilities at no cost to our project. We are also very grateful to WWF-Guyana for co-sponsoring the production on an animation for explaining the results of this project to the wider public, and to the Environmental Protection Agency, Guyana, for hosting our Stakeholder Workshop in February 2018.

Finally, this project would not have been possible without the significant support of Guyanese stakeholders and community members, including the North Rupununi District Development Board (NRDDB), and WWF-Guyana. It is thanks to the initiative taken by the NRDDB and WWF to lead on a series of stakeholder meetings and high-level ministerial engagement that we were able to redirect our project funding, originally targeted at stakeholder engagement, to fulfill other urgent objectives focusing on the scientific research. Specifically, this enabled us to officially engaged WWT-Consulting Ltd in providing technical advice and training on the hydrological modelling and the LoRa tracking technology.

A special thanks to Russian Dorrick, the Toshao of Yupukari Village, and the staff at Caiman House, Yupukari, for their support.

The following tables provide a summary of funds allocated and spent (Table 1), and a budget for spending the remaining project funds to December 2018 (Table 2).

Table 1: Summary of funds allocated and spent

Item	**Original Budget**	**Actual spend**	**Woodspring Trust contrib.**
International/national air travel	£3,000.00	£2,385.24	£156.14
Stakeholder workshops	£4,800.00	£0	£0
Salaries and sub-contracting	£13,550.00	£9,442.34	£9,442.34
Fieldwork logistics, accommodation and food	£4,500.00	£5,989.74	£5,989.74
Equipment (including drone and accessories) and training	£2,400.00	£7,937.81	£3,881.83
Spatial analysis software	£550.00	£1,532.91	£1,532.91
Dissemination in open access journal paper, conference and online (articles and video)	£1,200.00	£0	£0

Totals	**£30,000.00**	**£27,288.04**	**£21,692.21**

Table 2: Budget for spending the remaining project funds to December 2018

Budget May-December 2018	**Budget**	**Woodspring Trust contrib.**
Researcher salaries	£1,000.00	£1,000
Open access publishing	£1,200.00	£1,200
Animation on Rupununi Portal hydrological dynamics	£5,000.00	£2,000
Contingency	£557.79	£557.79
Total	**£7,757.79**	**£4,757.79**

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Appendix

Copy of letter sent by the North Rupununi District Development Board (NRDDB) to Hon. Sydney Allicock, Vice President & Minister of Indigenous People's Affairs, Government of Guyana.

NRDDB

NORTH RUPUNUNI DISTRICT DEVELOPMENT BOARD

BINA HILL INSTITUT

ANNAI AMERINDIA

REGION #09

RADIO CONTACT:
BRAVO INDIA -5300
FIELD STATION -7800
EMAIL: nrddb@yahoo.com

Hon. Sydney Allicock
Vice President & Minister of Indigenous People's Affairs
Ministry of Indigenous People's Affairs
251-252 Quamina & Thomas Sts.,
South Cummingsburg, Georgetown

October 2, 2017

Dear Hon. Vice President,

Re: Protection of the North Rupununi Wetlands

Further to our previous communications on the abovementioned subject (see attached), we are pleased to submit a detailed map of the proposed North Rupununi Wetland Area of Conservation Interest. On behalf of the North Rupununi District Development Board and the people of the North Rupununi, we are requesting that an "Area of Conservation Interest" be declared by the Government, as per the map, and that a time-bound pause be instituted on granting **new** concessions and leases in the Area.

This temporary moratorium will free up significant donor funding to support the NRDDB and our partners to initiate a multi-stakeholder planning process that will chart a green vision for the NRWetlands (see summary attached). Our goal is to identify integrated management options that adequately address competing commercial and livelihood interests in the area while conserving the critical ecosystem function and biodiversity (including the annual flooding cycle that renews the Rupununi's fish and freshwater resources) so vital to local people. This integrated management framework will be developed through research, dialogue and consensus building, and will be subject to Government input and approval.

The NRDDB feels that the creation of an integrated conservation and management regime for the North Rupununi Wetlands will provide an ideal testing ground for green enterprises and sustainable livelihoods initiatives that benefit local people. Lessons-learned from this initiative, along with the lessons learned during the planning process, will provide invaluable lessons to similar efforts in other parts of Guyana.

We look forward to the Government's approval of the Area of Conservation Interest, and to your continued support in our shared efforts to conserve this globally important landscape. By endorsing this initiative, the Government further demonstrates its tangible commitment to protecting the planet and genuine stakeholder engagement in sub-regional land-use planning, setting itself apart from the approach previously used to allocate land and resources in the wetlands without local input or knowledge. The NRDDB remains dedicated to our partnership with Government, and to working together for the conservation and sustainable development of the North Rupununi and its people.

Sincerely Yours,

…………………………..
for Chairman

Cc: Minister of State, Hon. Joseph Harmon