DAVIS EXPEDITION FUND

REPORT ON EXPEDITION / PROJECT

Expedition/Project Title:	**Paleoecological Reconstruction of Fire and Vegetation in the Coastal Savanna of Southern Belize**
Travel Dates:	January to May 2018
Location:	Deep River Forest Reserve, Toledo District, Belize
Group Members:	Cathy Smith (working with researchers from the University of Tennessee
Aims:	- Take cores of lake bottom sediments from a pond in the Deep River Forest Reserve Belize - Analyse the cores for charcoal fragments, pollen grains and stable isotope signatures to determine and interpret changes in fire activity, vegetation and climate over time - Use the results to inform present prescribed fire management in the Forest Reserve and nearby Payne's Creek National Park - Contribute to an existing regional literature examining quaternary climate, fire, vegetation and human land-use change

Outcome (a minimum of 300 words):-

Much of our knowledge of the history of climate, vegetation, fires, and human land use since the last glacial period derives from the study of the sedimentary archives formed at the bottom of lakes and ponds (Horn, 2007, Horn 2017). This involves coring lake-bottom sediments, dating them with radiocarbon or other means, and sampling and examining pollen grains, charcoal fragments, stable isotope signatures, and other environmental indicators or proxies to determine and interpret changes over time. This project focuses on fire and environmental history in the coastal savannas of southern Belize, from the study of lake sediments taken from the Deep River Forest Reserve (see figure 1). Today these savannas see near annual fires, largely set by local people, which have been deemed a conservation threat. Sediment core records can assist land managers and conservationists in determining the long-term role of fire in ecosystems and deciding whether present fire levels suggest the need to reduce ignitions or possibly add prescribed fire (Myers *et al*. 2004a, 2004b, Myers 2006, Dietl *et al*, 2015). My PhD research uses archival documents and oral history interviews to examine the history and politics of fire management in Belize, yet little is known about how fire frequencies in the savanna

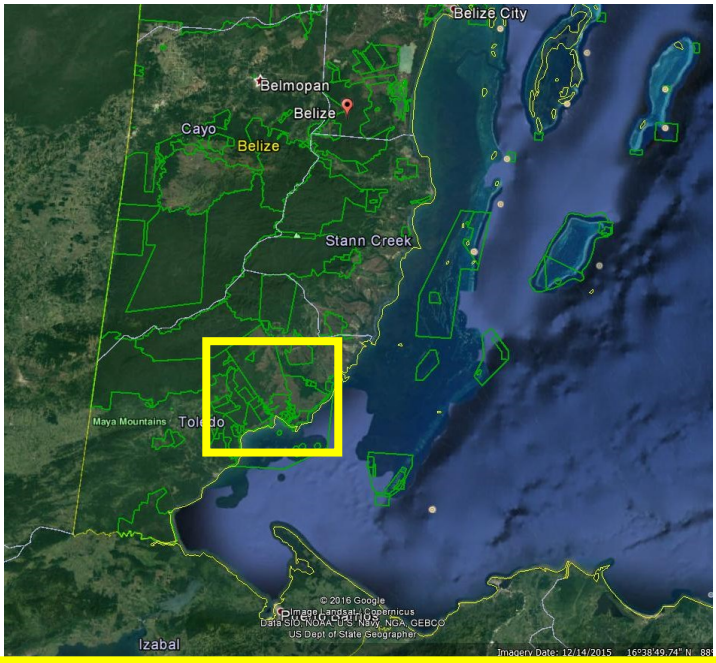
have changed over time or been affected by human land-use and fire management in the past. By providing the first paleoecological record in a Belizean savanna, this work complements my PhD study and can inform present prescribed fire management in the Forest Reserve and nearby Payne's Creek National Park.

Figure 1: Coastal savanna in southern Belize

Project description:

This project is a research collaboration between myself and Dr Sally Horn at the University of Tennessee in Knoxville, an expert in paleoecological reconstruction from lake sediments in the circum-Caribbean. Dr Horn and I are co-funding the research.

I was in Belize from January 2018, for my PhD fieldwork, and during this time obtained the necessary permits for the research from the Belizean Government's Forest Department and Geology Department. Dr Horn planned to join me in Belize in March to collect the sediment cores, bringing two masters students. Unfortunately, because of a medical emergency, she was unable to join me for the fieldwork, and her PhD student Mathew Boehm took her place. Mathew, and the two masters students joined me in Punta Gorda, Belize for 1 week on 18th March, bringing the majority of the equipment needed for the sediment coring with them. We spent 4 days at our field site 'Pine Pond' (see map figure 2) in the Deep River Forest Reserve to collect the sediment cores. During the fieldwork we based at a ranger station of the local NGO the Toledo Institute for Development and Environment (TIDE), with whom I am working in Belize for my PhD. We were assisted throughout our fieldwork by one of TIDE's rangers. TIDE also kindly loaned us lifejackets, ropes and a vehicle free of cost.



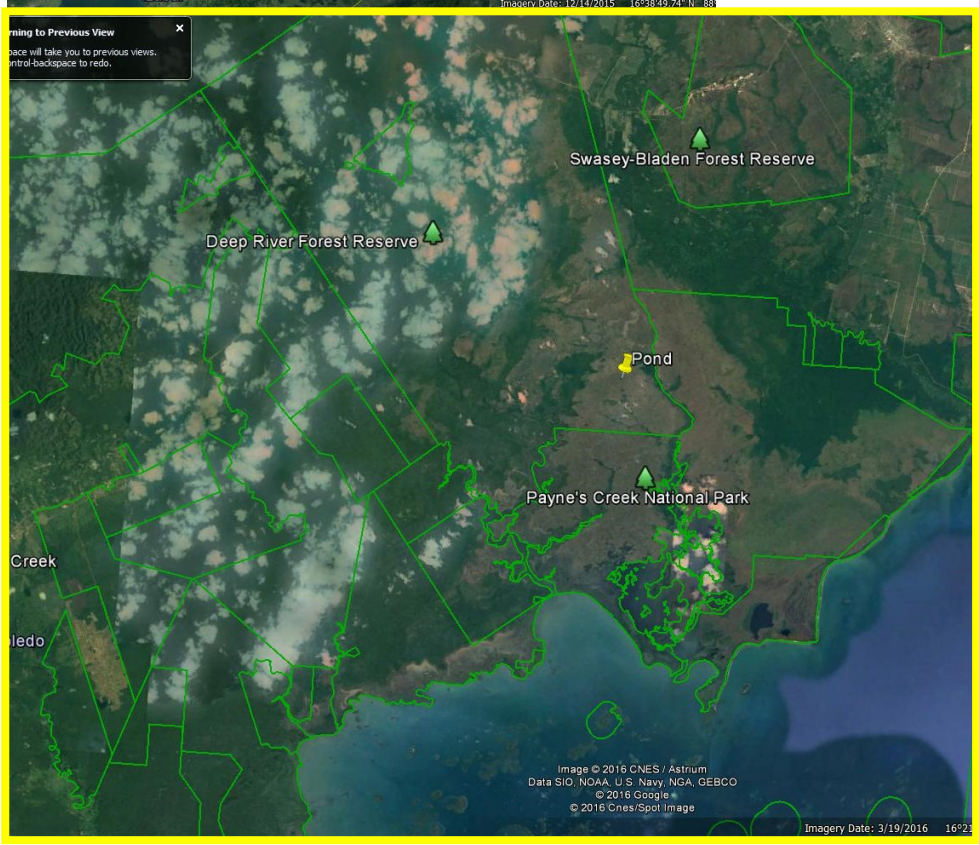


Figure 2: study area
To left- southern Belize and the Toledo district
Below- Location of Pine Pond at 16.3682°N, 88.6311°W, and surrounding reserves. Savanna ecosystem visible from its brown colouration.

To collect the sediment cores we constructed a temporary raft in the field to serve as our coring platform, using four truck tire inner-tubers, lumber and rope (see figure 3). After some initial set-backs with burst inner tubes, we floated the raft onto the pond (see figure 4). It was anchored using cement blocks and ropes to allow later adjustments to its position. We then used a small inflatable boat to transport ourselves and our equipment to and from the coring platform. From the platform we collected cores at two locations in the pond. First, we sampled the upper 'mud-water interface', extruding, in the field, 1-cm intervals from the upper metre of sediment into plastic bags (see figure 5). We then used a piston sediment corer to collect, in

1m drives, a further 2m of sediment at the first location (core 1), and 6m of sediment at the other location (core 2) (see figure 6).

Figure 3: Constructing the coring platform

Figure 4: The coring platform in place in the pond

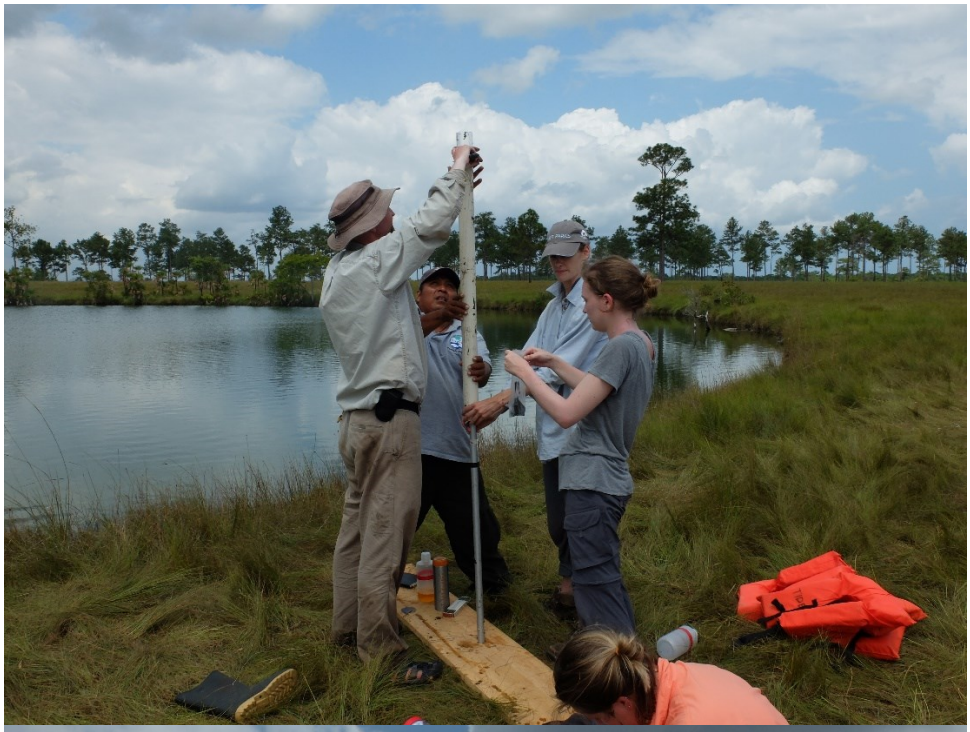


Figure 5: Taking 1cm samples from the mud-water interface core

Figure 6: Using the piston corer to take a sediment core

After the team from Tennessee had left I spent several more weeks in Belize and had the sediment cores shipped by bonded courier to Dr Horn's lab in Knoxville, Tennessee. I then travelled to Tennessee in April to spend two months living in Knoxville to begin the analysis on the cores, returning to the UK at the end of May. The analysis will take place throughout 2018 and into 2019, under Dr Horn's direction, with the continued participation of Mathew Boehm together with Dr. Horn's master's student Jacob Cecil. The cores will be analysed for macroscopic charcoal as a proxy for local fire activity, and for pollen and stable carbon isotopes as a proxy for past vegetation. This work will be the focus of Jacob's master's thesis, and will result in one or more journal articles for which I will be a co-author, together with

Horn, Boehm, and stable isotope expert Chad Lane at the University of North Carolina, Wilmington. I will also reference the work in my PhD thesis.
During my two months in Tennessee I worked with Jacob Cecil and Matt Boehm to open all of the core sections, to do initial core descriptions for both cores 1 and 2, and to begin the macroscopic charcoal analysis, which Jacob and I completed for core 1. We began by sawing each of the eight aluminium coring tubes (in which the sediment had remained during transport) in half, to reveal the sediment (see figures 7 and 8). We then took photographs of each core section. We made descriptions of each core section on a core log, describing changes in colour and sediment size, and noting the presence of large pieces of organic matter that may be suitable for radiocarbon dating (see figure 9). Radiocarbon dating allows us to put estimated dates against the histories we reconstruct.

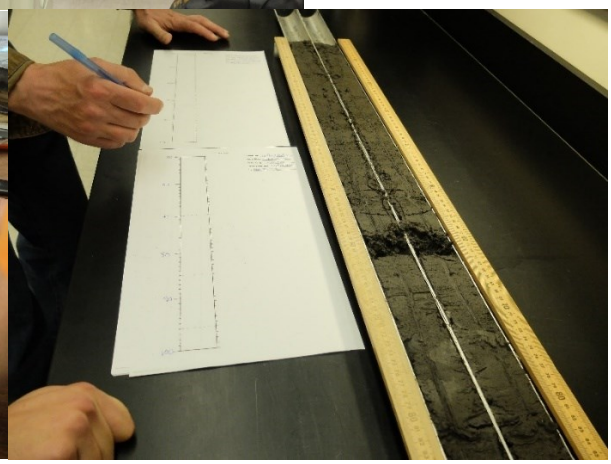


Figure 7 (left): Cutting open the aluminium coring tubes
Figure 8 (below left): The sediment inside the core is revealed
Figure 9 (below right): Describing the core on a core log

We then extracted the samples that might be suitable for radiocarbon dating and dried these in an oven (see figure 10). We then sent an initial two samples from core 2 for radiocarbon dating to Beta Analytic, which returned dates (with a 95.4% probability) of 4763 - 4627 cal BP for a sample at the base of the core and 1699 - 1553 cal BP for a sample about halfway up the core. These initial dates give us confidence that the core covers a significant time period and allowed us to make

informed decisions about sampling strategy. Before I left Tennessee, we sent a further five samples for dating from cores 1 and 2, and we expect the results in August 2018. Additional samples will be sent for dating later in the year on the basis of the results from the earlier samples, and the ongoing analysis.

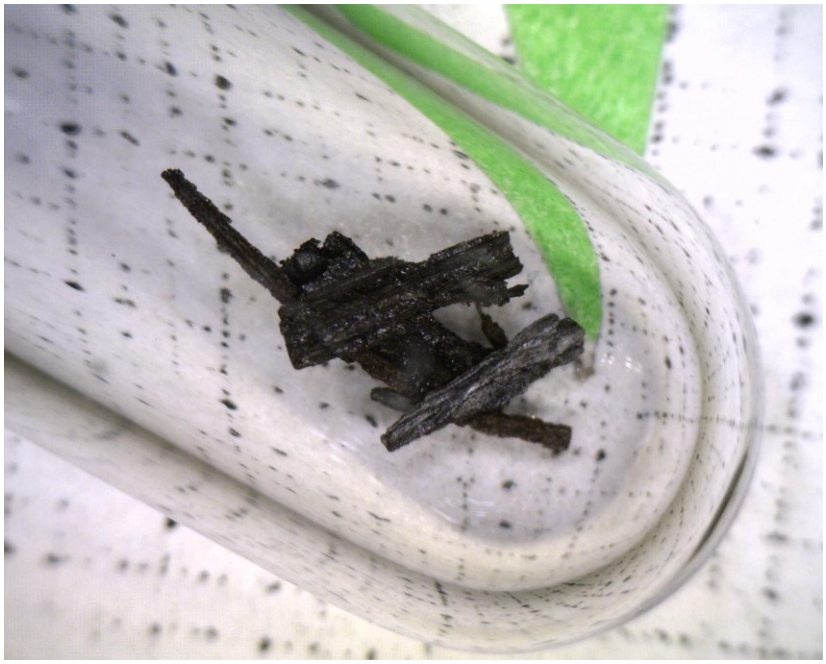


Figure 10: Sample of charcoal from core 2, sent to Beta Analytic for radiocarbon dating

We began the microcharcoal analysis by sampling 2cm^3 fractions of sediment along the length of core 1 (See figure 11). These were left overnight in 3% hydrogen peroxide to deflocculate (see figure 12). We then sieved each sample at 250 µm and dried the sample overnight in an oven at 60 degrees Celsius (see figures 13 and 14). We then examined each sample under an optical microscope and counted all fragments of charcoal present. Charcoal was identified relative to other fragments and sediment in a sample by its opaque black colour and sheen (see figure 15).

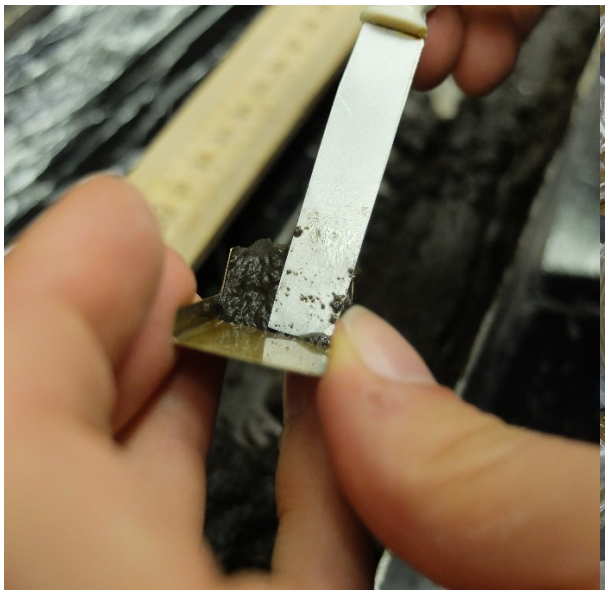


Figure 11 (left): Sampling

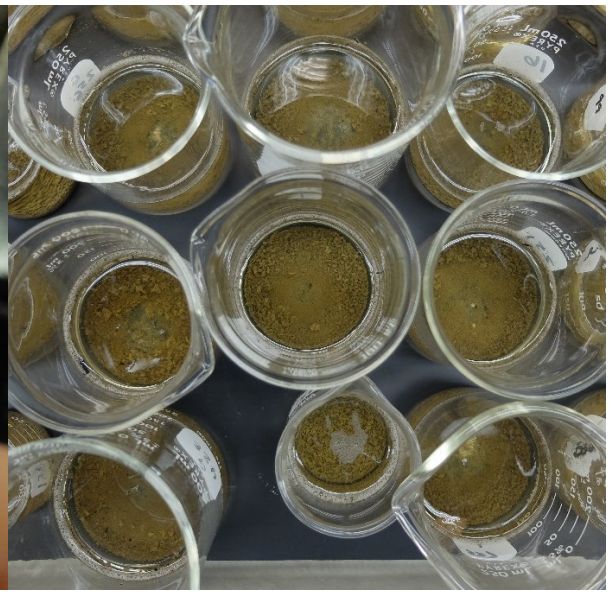


Figure 12 (right): Samples de-flocculating

Figure 13: Putting a sample through a 250 µm sieve

Figure 14: A sample, dried and ready for charcoal counting

Figure 15: View of a sample under the dissecting scope. The opaque black fragments are charcoal

Findings to date and plans for continuation and dissemination of the research:

Figure 16 shows the preliminary results of the microcharcoal analysis for core 1, which I completed together with Jacob Cecil while I was in Knoxville. As we do not yet have radiocarbon dates for these core sections we can only estimate the age of the record. If the rate of sedimentation at core site 2 indicated by our first two dates is a good estimate for the lake as a whole, then our record from core site 1 could span approximately 1000 years. Later this year we will have radiocarbon dates for core 1, as well as climate and vegetation analyses, which will inform analysis from this data. But the presence of macroscopic charcoal in almost every sample indicates fires throughout the deposition of the sediments in the core. The variation with depth suggests a changing fire frequency, for reasons that we hope to explore. An event that we will be looking for evidence of in this record is the periods of drought associated in other studies with the Terminal Classic Drought (see Kennedy and Horn, 2008, Lane, Horn and Kerr, 2014, Lane *et al*, 2011).

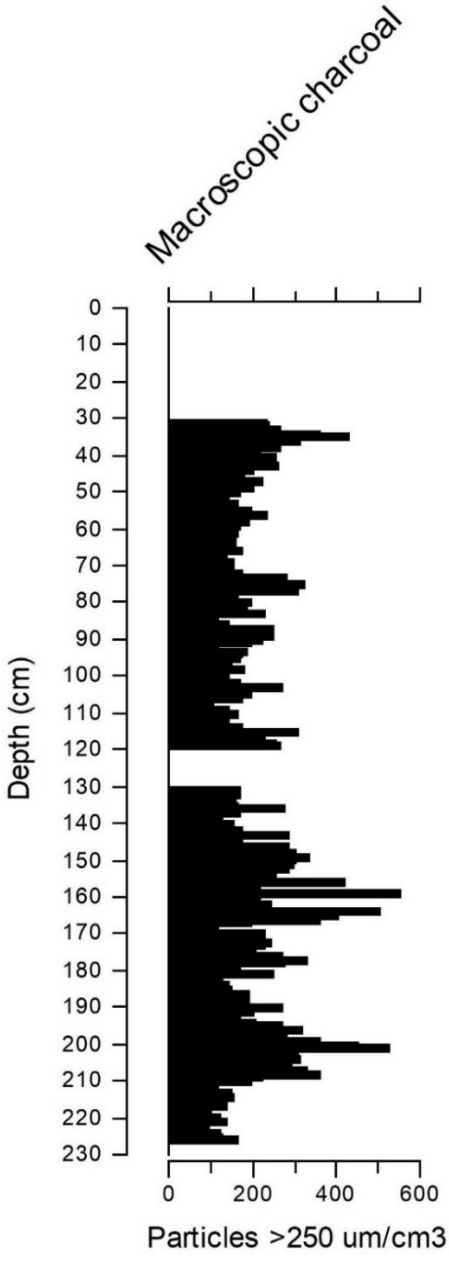


Figure 16: Macroscopic charcoal by depth for core 1

The macroscopic charcoal analysis for core 2 as well as pollen and stable isotope analyses will be carried out on the core in the remainder of 2018 and into 2019 by Jacob Cecil, Sally Horn, and Matt Boehm in Knoxville (with isotope samples run by Chad Lane in Wilmington). I am making plans to return to Knoxville in January 2019 to assist further with the analysis and data interpretation. We will co-author our first paper from the analysis in 2019. This will be the first published sediment core record from a savanna in Belize (Rushton *et al,* 2012 and Walsh *et al,* 2014 having published the only other core records, but from broadleaf forest). The work will contribute to an existing regional literature examining quaternary climate, fire, vegetation and human land-use change and have local management implications for the Forest Reserve and National Park.

I aim to hand in my PhD thesis by early 2019, and so the full sediment core analysis will not form part of my thesis. However, I will reference the work in my thesis and the fire management history I am writing for my thesis will help inform interpretation of the sediment core data in 2019. I also plan to return to Belize in 2019 to present my research findings, including the results of the sediment coring, to TIDE and the Belize Forest Department. After 2019 the core will be kept in storage and it is likely that it will be used by Dr Horn in future projects to complement studies her research team are doing in other areas of the circum-Caribbean.

Final budget:

My Funding Sources	**Value (£)**
Davis Expedition Fund	1700.00
My PhD Research and Training grant	800.68
Monica Cole Research Grant (Royal Geographical Society)	1000.00
Centenary Agroforestry 89 Fund (University of Edinburgh)	1000.00
Total:	**4500.68**
Expenditure	**Amount (£)**
My round-trip flights to Belize (including the 2 month stop in Knoxville)	724.43
Airbnb on layover in Houston on route to Belize	40.00
Food for sediment coring team for 3 days of sediment coring	45.00
Fee for research permit from Belize Forest Department	72.00
Contribution to TIDE for ranger assistance for 3 days of sediment coring	54.00
Cost of cement blocks to weigh down raft	7.00
Transport by chartered van of coring equipment and samples between Belize City airport and Punta Gorda	502.00
Bus tickets between Punta Gorda and Belmopan to obtain research permit and export permit for core samples	32.00
Round-trip on greyhound bus from Atlanta to Knoxville	35.25
Airbnb for 8 weeks in Knoxville	979.00
Contribution towards radiocarbon dating of cores (my contribution covered 6 dates)	2010.00
Total:	**4500.68**

The research was co-funded by Dr Horn, who provided all of the coring equipment and contributed $8000 (£6030) from three grants she and her students were awarded (a Franklin Grant from the American Philosophical Society, the Mel Marcus Grant from the American Association of Geographers, and a grant from the

University of Tennessee's McCroskey Fund). These funds plus additional research funds Horn has available covered her students' flights, their accommodation costs and subsistence costs on non-fieldwork days in Belize, fuel for the vehicle we used on the days of the coring, the lumber for raft construction, shipping the cores with FedEx to the US, all laboratory costs in Tennessee and a contribution towards the radiocarbon dating of the cores.

References:

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