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RESEARCH ARTICLE

Past and Future Earth: Archaeology and Soil Studies on Ambergris Caye, Belize

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Marco Gonzalez is one of a number of Maya sites on Belize's coast and cayes (coral islands) that exhibit anomalous vegetation and dark-coloured soils. Like Amazonian Dark Earths (ADEs), the soils are sought locally for cultivation and are underlain by anthropogenic deposits. Our research is aimed at assessing the role of the anthropogenic deposits in soil formation processes with a view to developing strategies to quantify the long-term environmental impact of human activities today.

Introduction

Archaeological soil and sediment studies complement archaeological excavation, and the attendant analyses of recovered artefacts, in order to paint as detailed a picture as possible of past environments. A layer of dark-coloured soil, for example, underlying a Maya plaza compound tells us that the structures were built directly on a former land surface, which in turn can be tested for pollen or carbonised organics. In another context, a build-up of wind-borne sands could indicate desertification or destruction of forest or plant cover. If areas in the past were periodically flooded, resulting in the presence of standing water, we would know because the sediment particles would be sorted by size. Although archaeologists attempt, through excavation, to collect all possible artefacts or bones or detritus left behind by people in the past, micromorphological studies of soils or sediments (see the thin section in **Fig. 4** below) provide levels of detection not possible with the naked eye. Thus materials can be identified such as coprolites (fossilized faeces with the remains of digested food) or microscopic inclusions (such as marine shell fragments, which would reflect inundation by the sea). Other kinds of analysis reveal the chemical properties of soils, which in turn can tell us about the effects of past farming or industrial practices.

In our case, however, the past is not our sole concern. We are interested in reconstructing the ancient environment but also in determining the ways in which people acting in these environments affected—through

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the deposits they left behind—the genesis of modern soils and their fertility. A focus on what makes soils cultivable means that we need to be able to shift perspectives. In addition to viewing soils or sediments as the matrix for archaeological objects and deposits, we are viewing archaeological objects and deposits as potential soil parent material.

The site

'Marco Gonzalez' is the name of a Maya archaeological site on the southern tip of Ambergris Caye, a coral island that lies off the north coast of Belize and is bordered to the windward by a barrier reef (**Fig. 1**). The site boasts a long history, but what first drew us to the slightly kidney-shaped mound, ca. 340 m by 160 m, were its dark soils and distinctive vegetation. The soils are sought by locals for their gardens, and the vegetation clearly stands out from the surrounding mangrove swamp. The local soil parent materials of Pleistocene reef limestones (James and Ginsburg 1979; Gischler and Hudson 2004) could not have been responsible naturally for the dark-coloured earth, and we hypothesised that the surface soil may have formed in a way similar to the *terra preta* or Dark Earth of the Amazon (ADE), which is clearly linked to human activity (Arroyo-Kalin 2012; Glaser and Woods 2004; Lehmann et al. 2003).

We set ourselves four aims. The first was to discover—through archaeological excavation—how the sediments at the site had accumulated. The second was to learn how the modern-day surface soils had formed. The third aim involved characterising the vegetation cover. Our previous excavations had already pointed to substantial anthropogenic contribution—that is, effects of human activity—to the depositional profile, and we wanted to explore whether we could establish any associations between species (or communities or vegetation diversity) and the soil or sub-soil qualities. Finally, because our results could have implications for modern environmental planning, we aim to continue to work on developing methods of quantifying inputs and outputs over time by detailing what sorts of materials were left by the inhabitants, what forces acted on the deposits, and what constituents in the sediment profile were potentially entailed in soil genesis.

Figure 1: Map of Belize. The site of Marco Gonzalez is located at the south end of the island of Ambergris Caye, ca. 6 km south of San Pedro Town (Reproduced with permission of www.worldatlas.com).

Soils and sediments

Archaeological soil and sediment investigations were first developed in the 1960s in order to understand better past environments and the archaeological contexts (soils and deposits) in which archaeological materials such as ceramics and bones, occur. Studies include all scales – field scale to the analysis of deposits at the microscale (thin section microscopy). Both chemical (organic matter, phosphate, pH, 'salinity') and physical properties (particle size and magnetic susceptibility) are also measured in what is termed 'geoarchaeology'.

Soils make up much of the earth's surface:

> The soil is a natural body of animal, mineral and organic constituents differentiated into horizons of variable depth which differ from the material

> below in morphology, physical make-up, chemical properties and composition, and biological characteristics. (Joffe 1949: XX–XX)

When someone mentions 'archaeology', the image that comes to mind is people scraping away soil and digging things up out of the earth. Archaeologists' focus is normally on the *things* that are excavated: objects of all shapes and sizes, usually broken and worn, from a range of early cultures and civilisations; burials and their contents; animal bones; plant remains; and of course ruined structures. The fact that archaeologists have to *dig* for things is taken for granted. We talk about sites and objects being buried, but the question is, how do they get buried? Why shouldn't all the objects used by the Maya or the Romans still just be lying around for us to collect? Where does the material originate that, in time, 'buries' the abandoned house or plaza or temple?

As in Joffe's definition, soil is considered to be a natural body. But is it natural owing to the processes by which it is formed (climate, organisms, topography, parent material, time [Goldberg and Macphail 2006: 52]) or owing to its content? Is it safe to assume that the matrix in which archaeological material is found—and indeed the cultivable earth—is as natural in content as it is in its formation? Archaeological deposits are considered sediments, not soils, because they involve constituents resulting from human activity—ceramics or obsidian, for example—become eroded, shifted (or transported), and redeposited, whereas soil forms *in situ* through weathering and biological processes (Goldberg and Macphail 2006: 46). In assessing cultivability, however, if soils in which plants or crops are grown derive nutrients from (or indirectly owe nutrient or water capacity to) elements that have their origins in anthropogenic deposition, it becomes difficult to separate the cultural from the natural. Scientists have been somewhat successful in keeping separate the threads of culture and nature by devising a term to characterise soils influenced by human activity: *anthrosols*. But is the enriched soil at Marco Gonzalez an anthrosol? According to the Food and Agricultural Organization of the United Nations (FAO), anthrosols are soils that were *deliberately* formed or modified for cultivation through long-term human activity such as the intentional addition of organic materials or household wastes. Exemplified by the dark earths formed in Europe, anthrosols have an enhanced acid-soluble phosphate content (Borderie et al 2014; Goldberg and Macphail 2006: 270–273, 347, table 3.2; Soil Survey Staff 1999) and human influence is generally seen to be restricted to the surface horizon (FAO). The Marco Gonzalez soils, however, are not intentionally enriched and therefore are not, strictly speaking, anthrosols. Furthermore, evidence suggests that the dark soils at the site—which lie beneath a shallow mantle of humic, biologically homogenised surface soil—owe their character to *in situ* dynamics that draw (naturally?) upon deeply buried anthropogenic material, so that anthropogenic influence is not a feature of a restricted surface horizon.

The earth as transformed by human action

There are processes in nature that are mimicked or duplicated in human behaviour, and this enables us to bridge the culture-nature divide and assess input that results from human activity in the same way we would assess any soil parent material. Metamorphism, for example, describes the process whereby rocks on the earth's surface are exposed to conditions of extreme temperature or pressure—enough to change their chemical composition and produce a different rock altogether. Both metamorphic and igneous rocks can act as soil parent material. If we view humans as capable of changing the chemical composition of naturally formed substances, then there may be circumstances in which the debris and detritus of human activity should be included not as *deliberately acted upon* in the formation of soil (Goldberg and Macphail 2006) but as elements or particles derived from a parent material and thus part of the soil matrix itself.

Human action has had significant impact on the planet (Thomas 1956; Turner et al. 1990), but the consequences most widely recognised and measured are negative: soil erosion, land degradation, pollution, biodiversity loss, and greenhouse gas production (Goudie 2006). It is acknowledged that humans can improve soils through additives, but the driving force behind our research is the hypothesis that unintentional consequences of human depositional activity can, under certain conditions, also result in soil enrichment (Arroyo-Kalin 2014a; Graham 1998). What these conditions are is what the work at Marco Gonzalez is all about. It may seem odd at first to look to the past in the humid tropics to address modern problems largely generated by people and cultures of temperate regions (pollution from gas, oil or coal; discard of plastics; poisonous industrial waste; greenhouse gas production) (Graham 2006), but we have what we argue are good reasons: the nature of decay, rapid regrowth of vegetation, a profusion of animals, lots of people and their rubbish, and a particular kind of industrial activity that entailed charcoal deposition.

Decay processes in the humid tropics are rapid in comparison to temperate climes. Plastic fragments may lie for years behind a bush in a garden in Somerset, but not in Belize. Therefore we have a bit of an edge in tracking the chemistry of decay, because time is considered a major soil-forming factor (Goldberg and Macphail 2006: 52). Vegetational regrowth is also more rapid in Belize than in London or Leiden. Plant species are good indicators of soil quality, but vegetation communities and diversity can potentially tell us even more about soil characteristics. This is not to say that we are not studying soils directly but only that vegetation can lead us to look in the right places. Fauna, too, have a lot to tell us about the local environment. As the first European explorers discovered, the humid tropics abound in animal life. We have not yet taken up the subject of the effects of insects on soils, but work by a UCL undergraduate already points to the important role of land crabs (*Cardisoma guanhumi)* in soil bioturbation (Glanville-Wallis 2015) (**Fig. 2**).

Although Marco Gonzalez is situated in what would seem at first to be a peripheral location, its history was structured by the demands of an urban society involving large numbers of people with a wide range of tastes and needs moving goods and materials over long distances. Missing from our deposits are excreta and bones from herds of grazing animals (there were none in the Neotropics), and we have no wheels from carts (there was no wheeled transport), but the deposits at the site reflect intensive local, mainland and circum-peninsular activity. There were dense populations on the caye, and locals were receiving goods and providing services for dense populations on the mainland. Tortilla and taco takeaways had not yet been packaged in polystyrene, but locals threw a lot of stuff away, and also carried out intensive production which generated a good deal of waste. One of the cultural activities at Marco Gonzalez, described in more detail below, was salt production. Salt-making has always been a feature of the island's history, but between about A.D. 550–750, the process intensified to the point at which salt was produced in large quantities and exported to the mainland. More important to our

Figure 2: Phil and Cesca excavating a land crab (*Cardisoma guanhumi*) burrow (Photo Mark Wheeler).

research is that boiling the brine to prepare the salt for export involved intensive burning of fuel. The spent charcoal was then swept aside and buried by new production layers. It is this charcoal that seems to be the source of organic compounds that were available to aid plant growth.

The cultural history of Marco Gonzalez

In 2013–14, generously funded by a grant from the Leverhulme Trust, we began the first stage of what we hope will be a long-term project aimed at discovering the ways in which archaeological deposits have contributed to soil formation processes, with a particular focus on surface soils and their fertility. The case-study site of Marco Gonzalez was selected for several reasons. First, Marco Gonzalez is one of a number of sites along Belize's coast and cayes that exhibit the anomalous dark earth with its distinctive vegetation suite. Another criterion is the fact that the location of the site on a coral island meant that we could distinguish what to expect in terms of natural soil formation processes more easily than would be the case on the mainland. Finally, and not least important, excavation had been carried out at Marco Gonzalez in 1986, 1990 and 2010; this gave us a basic idea of the chronology of the site as well as the cultural connections of its inhabitants (Graham 1989; Graham and Pendergast 1989; Graham and Simmons 2012; Pendergast and Graham 1987; Simmons and Graham 2016).

Like other sites on the caye (Guderjan and Garber 1995), Marco Gonzalez was occupied from at least 300 B.C. (**Table 1**). We say 'at least' because earlier deposits that we have not yet been able to access lie below the water table. The time between about A.D. 1 and 250 saw intensive occupation, trade, and fishing activity, followed by construction of platforms for houses, and presumably civic and ritual structures, between about A.D. 250 and 550. Pottery recovered is typical of the kind that was transported in large quantities in canoes along the coast during this period and then moved inland. At some point in the 6th century A.D., the focus changed dramatically to salt production. Layers of sherds from quartz sand-tempered ceramic bowls (named 'Coconut Walk unslipped' [Graham 1994: 153–156, Figs 5.7, 5.8]) were found alternating with levels of charcoal and ash; the indication is that brine was heated in the pottery vessels to drive off water and prepare the salt for shipment. Salt production seems to have been the dominant activity throughout this period (the Late Classic) until the latter part of the 8th century, when the site's occupants began to construct what would turn out to be over 40 buildings—stone-faced, terraced platforms that supported wooden superstructures—directly over the salt production debris, incorporating the debris into the core of the platforms. As was the custom among Precolumbian Maya, the dead were buried beneath the plaster floors of the houses; we have over 35 burials from a portion of one house alone. Widespread trade and exchange activity continued to flourish during this period from about A.D. 800 to 950, apparently while Maya were abandoning communities such as Palenque and Tikal on the mainland as a concomitant of collapse. Occupation continued from the 10th into the 11th and 12th centuries, but by 1200 to 1250, mangrove encroachment

Time	Maya Periods
1544–1648	Early Spanish colonial
1492–1544	Terminal Postclassic
1350–1492	Late Postclassic
1200/1250–1350	Middle Postclassic
960/1000–1200/1250	Early Postclassic
750/800–960/1000	Terminal Classic (Maya collapse)
600–750/800	Late Classic
250–600	Early Classic
A.D. 1–250	Terminal Preclassic
300 B.C.–A.D. 1	Late Preclassic
600–300 B.C	Middle Preclassic

Table 1: Marco Gonzalez chronology.

reached an unmanageable level (Dunn and Mazzullo 1993), making the site unsuitable as a port. The local population dropped, and people probably moved the 6km north to the community at San Pedro (see **Fig. 1**). Ceramics recovered from residential remains, from surface scatter, and from an offering in a historic-period addition to one of the buildings, however, tell us that a low level of occupation continued until the 16th century.

What we have learned so far

Knowing the culture history has given us the time frame for our study. This, coupled with some understanding of the range and diversity of activities carried out by the people who lived at the site over time, has enabled us to come to some conclusions about the sediments, whether and how they changed over time, and the ways in which they contributed to soil formation processes. In addition to expertise in archaeology (Elizabeth Graham), individuals have brought expertise in soil micromorphology (Richard Macphail), soil chemistry (John Crowther), palaeolimnology and sedimentology (Simon Turner), environmental engineering and impact modelling (Julia Stegemann), Amazonian Dark Earth studies (Manuel Arroyo-Kalin), palaeobotany (Lindsay Duncan, Phillip Austin, Bronwen Whitney), and botanical studies (Richard Whittet and Cristina Rosique). Here we attempt to summarise key aspects of our results. Details on the sampling and methods can be found in our articles describing the initial results of the research (Graham et al. 2015; Macphail et al. 2016). **Table 1** shows calendar-year equivalents of the periods mentioned.

One outcome of the research is recognition of the sheer quantity and density of anthropogenic deposition (**Fig. 3**). In some circumstances, what appeared to be undifferentiated sediment or soil to the naked eye was shown by soil micromorphology to comprise packed fragments from floors, fish bone, pottery, and even coprolites. **Figure 4**, for example, is a scan taken by Richard Macphail of a thin section of a deposit from Op 13-1 (see **Fig. 3**). The yellowish, thick horizontal layer

Figure 3: Lindsay (foreground) and Liz in Op 13-1 test pit. Photo looks N (Photo Marco Gonzalez Project).

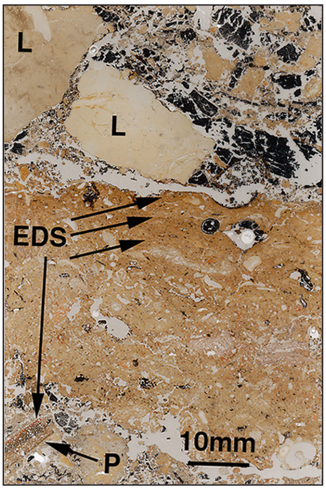

Figure 4: Flatbed scan of thin section (M3B), Str. 14, Op 13-1, west face. Energy dispersive X-Ray spectrometry (EDS) studies were carried out on pottery samples and the plaster floor. Scale bar = 10 mm (Photo Richard Macphail).

in the scan is a Late Classic lime plaster floor overlain by coarse limestone clasts (rock fragments) (L). The black fragments are charcoal fuel residues from salt production, and of the tiny pink bits, some are plaster fragments and others are bits of sediment from nearby tidal flats, where the salt was collected. The floor overlies a deposit that contains a sherd of Coconut Walk pottery (P) used in the final stage of salt production.

Although the lowermost archaeological strata lay below water level (water can be seen at the base of the test pit in **Fig. 3**), test pits and coring enabled us to identify infilling of low ground with ash and fine, bone-rich colluvium in the Terminal Preclassic to Early Classic period. There is also evidence that sediments and floors were exposed to the elements for a time. Major ground-raising of at least another metre occurred in Late Classic times, evidenced by alternating 'pink' lime floors and charcoal-rich ash layers. In these strata, lime floors—which include burned shell—were reddened by small fires, now patchily preserved as very thin ash and charcoal layers. The lime floors, ash, and charcoal layers are believed to be processing remains associated with salt working. Hyposaline salt water from salt pans or tidal flat sediments was the brine source, as indicated by intact sediment coatings on vessel fragments. The brine was then gently heated in the vessels over small fires. The salt-processing hypothesis is consistent with the marked presence of the reddened tidal-flat sediment clasts in the burned debris layers, which exhibit a high salinity and very strongly enhanced magnetic susceptibility.

Only ghosts of lime floors remain in the archaeological levels. Occupation debris (burnt bone, coprolitic material, conch shell) and processing debris (burnt sediment, fused ash, pottery) occurs within a dark humic and highly biologically worked soil. Finely fragmented charcoal originating from the Late Classic processing levels contributes greatly to the anomalous colour of the dark earth. Weathering effects, including rain and humic acid-associated leaching, exacerbated by tree root, land crab, and inhumation disturbances—which can deeply penetrate buried levels—have affected both the characteristics of the dark earth and the modern surface soil. In these ways, and owing to the high carbonate contribution from the carbonate-rich lime-based floors and ash remains, the Marco Gonzalez dark earth differs from typical Amazonian Dark Earths (Arroyo-Kalin 2014b).

Analysis of surface soils, combined with archaeological and site-marginal wetland contexts, has provided both spatial and temporal information on the interplay between anthropogenic and environmental processes involved in coastal sedimentation and soil development. The stratigraphy and inorganic geochemical record of coastal wetland cores shows that the deposition by humans of waste products—generated from occupation, disturbance, and exploitation of coastal resources—paralleled, and is likely to have contributed to, transgressive sedimentation at the site. Elevated levels of mercury and other trace metals in the most recent (upper) archaeological contexts in places near structures, and incorporated into transgressive mangrove sediment, might suggest direct mercury usage by the Precolumbian Maya, but it is more likely that the elevated levels are an indirect contribution, perhaps from concentrated fish bone deposits. This is a complex issue, however, and analyses are ongoing to determine more definitively the origin of the mercury and trace metals.

To complement the information recovered from sediment cores, flotation of archaeological deposits was carried out to recover charred palaeobotanical remains. Initial analyses support the characterisation of the lowest Terminal Preclassic levels as colluvial wash of midden material. Foodstuffs identified are *Zea mays* (maize), both kernels and cob fragments, and fruit stone fragments of *Byrsonima* sp. (nance or craboo) and *Spondias* sp. (plum). Fragmentation of the archaeobotanical material provides a good indication that deposits were being reworked after deposition, thus contributing to soil formation dynamics.

The salt-processing levels contain mostly charred wood, which supports the notion of an industrial activity with fuel requirements, although well preserved wood charcoal macro-remains have been recovered from most phases of activity at Marco Gonzalez. The identity of the woods represented as charcoal fragments can be determined through examination of their anatomical features (anthracology). The wood remains are being studied to recover information concerning the past composition and character of the local vegetation and to understand on-site fuel use. The period of salt production (ca. A.D. 550–760) is of particular interest and is the main focus of the anthracological study. Salt production is most likely to have been carried out using the *sal cocida* method: salt-rich sea water was heated in ceramic containers over a wood-fuelled fire to evaporate the water and leave a dense salt residue. The large scale and long duration of salt production at Marco Gonzalez mean that wood consumption would have been consistently high, almost certainly more so than during any other occupation phase. Diachronic wood analysis is an effective means of identifying the long- and short-term environmental impact of such intensive wood use and also contributes to our deeper understanding of shifting ecological processes at the site. Preliminary results from the anthracological analysis show that the most commonly used woods were those derived from mangrove vegetation, notably buttonwood (*Conocarpus erectus*) and white mangrove (*Laguncularia racemosa*), although propagule fragments (material used for plant propagation) from red mangrove (*Rhizophora mangle*) have been recovered from wet sieving. These small trees are found today, alongside black mangrove (*Avicennia germinans*), in the extensive mangrove community that fully encircles the site. When completed, the wood charcoal investigation will have identified the range of fuel woods used and the impact of past wood exploitation on the contemporary vegetation.

Pottery sherd material from wet sieving was subjected to XRF compositional analysis. Results show that the most friable sherds were from the salt-production-related Coconut Walk unslipped vessels. These vessels were tempered with quartz sand (not found on the caye), and contain some of the highest levels of zirconium and zinc of all pottery tested. As these friable ceramics are the most likely to degrade into sediment material, they are a viable candidate for the quartz sand and mineral soil elements found via the sediment coring and observed also in soil micromorphological thin sections, although we have not yet ruled out a role for aeolian deposition (Cabadas-Baez et al. 2010).

The procedure of assessing the contribution of anthropogenic material—or any material brought to the site by humans—to the sediment profile is part of a wider effort to assess environmental impact. Life Cycle Assessment (LCA) is a material flow-based technique that is used today to examine the projected environmental impact of a production cycle. The ‘production cycle’ in our case is the sum of Maya activities and the attendant debris or waste. In the case of Marco Gonzalez, we already know that the modern land surface (the sum) comprises a dark earth that could not have been formed under natural conditions. LCA modelling is being used to define the boundaries of the analysis (space and time), and to produce an inventory for each stage of the full production cycle (the various activities at the site over time). The compositional analysis of the pottery fragments is an example of the quantification of material inputs and outputs. The aim is to assess environmental impact at each stage. The categorised environmental impacts should then facilitate the evaluation of all potential environmental impacts from all activities and waste. Identification of the potential for impact initiates the process of connecting observed environmental changes in the archaeological record to the state of the current environment.

The vegetation of Marco Gonzalez differs markedly from its surroundings. Encircled by a mangrove swamp, the site is an area of broadleaved woodland unlike any other vegetated areas observed on Ambergris Caye. The current vegetation was recorded in 2014, including a full list of all the plant species found. One species, *Quadrella incana* (a tree from the caper family) is a new record for Belize. We conducted other, structured surveys in order to investigate whether or not the existing plant communities allow us to make inferences about the ways in which vegetation has developed, whether there are patterns to be recognised, and whether these patterns reflect the site's cultural history and its soil characteristics.

Four longitudinal transects passing through the centre of the site were undertaken as well as a series of plots. The results of the plot surveys indicate that the vegetation on the site can be divided into four discrete sub-communities, each with its own indicator species. The edge of the site, bordering the mangrove swamp just above sea level, is characterised by salt-tolerant shrubs and graminoids (grasses and sedges). The woodland on higher ground in the interior clusters into two groups, which seem to differ owing to the density of the canopy. One group is characterised by small shrubs (*Picramnia antidesma* and *Psychotria nervosa*), able to grow in dimly lit spaces on the forest floor, whilst the other group is darker and denser, characterised by high forest trees, such as gumbolimbo (*Bursera simarouba*) and wild guaya (*Melicoccus oliviformis*). The final sub-community may be a relic of recent management and is characterised by widely spaced sapote (*Pouteria campechiana*) and black sage (*Cordia curassavica*) trees. Clearing parts of the site for excavation and tourism also seems to have encouraged widespread colonisation of saltwater palmetto (*Thrinax radiata*), which grows in abundance throughout the site except in the dense forest areas.

Owing to the site's unique character, its delimited area, recent disturbances to vegetation, and the unpredictable nature of the environment at short timescales (especially storms), it was difficult to test hypotheses based on the plants present on the site today. There are clear qualitative differences from other vegetated areas on the island and it seems very plausible that the differences are associated in some way with the presence of Maya Dark Earths, which have potentially created the right soil and microclimatic conditions to enable this vegetation type to exist amongst mangrove swamp. Ideally, however, further investigation of other sites in Belize with dark earths, and characterised by vegetation that is distinct from the surroundings, will be necessary.

Future directions

At this stage, we continue to publish preliminary findings (Graham et al. 2015; Macphail et al. 2016) but we are also in the process of designing a larger-scale project. We would like to expand excavations at Marco Gonzalez in order to characterise fully the intensity of activity at each stage of development and thereby capture the complete range of input from the anthropogenic materials, as this information will contribute to the robustness of the LCA model. We would also like to apply our research strategy to other sites with dark earths and distinctive vegetation on the cayes and atolls, but at a site or sites where the soil parent materials do not derive from coral or limestone substrates. Although the vegetation suite at Marco Gonzalez is unique, there are other sites on Ambergis Caye, on nearby smaller cayes, and on Belize's three atolls with dark earths and/or with plant and tree growth that differs markedly from the surrounding vegetation. Although individual site histories reflect varying degrees of clearing and management, tree and plant species and communities also reflect the history of the localised substrate—that is, the localised buried anthropogenic deposits, their origins, and their breakdown. If studies such as ours prove fruitful in terms of connecting the remains of inadvertent human activity to the genesis of soils, then assessments of what makes soils fertile and what makes agriculture possible may warrant re-thinking, as does what we do with our rubbish, our dead, and our waste, and how we manage the detritus of human activity over the long term.

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Competing Interests
The authors declare that they have no competing interests.

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