10 The waste of time

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Introduction

In this chapter, we use archaeology to introduce a new dimension to perceptions of waste that draws also from soil science and environmental engineering. We start by connecting our view with generally accepted concepts of waste. We then expand on our perspective and discuss potential implications for the disciplinary imperatives of both archaeology and soil science, and for common assumptions about dirt and soil. Finally, we present the interim results of experimentation with a model, known as Life Cycle Assessment (LCA) (European Commission 2010; European Environment Agency 1998; Finnveden et al. 2009; ISO 2006a, 2006b). LCA is a tool employed in modern assessments of potential environmental impact, from bio- and renewable energy (e.g., Cherubini and Strømman 2011; Pehnt 2006; Sander and Murthy 2010) to construction (Vilches et al. 2017) to landfill (Nielsen and Hauschild 1998, 158). In our case, the archaeological site, along with its dark soils and vegetation, represents the end-result or impact, and our interest is in reconstructing what led to the impact.

Our initial aim is to use the data recovered on the origins and constituents of past deposits to understand the processes of site formation, because the "site" as we know it today is defined by the impact of past discard behaviours. Our ultimate goal is to be able to contribute to the management of modern buried waste as well as the management of human burial by contextualising decay processes in "archaeological" or long-term timeframes. Internalising the significance of this long-term context will require changes in social and cultural attitudes. In addition, taking such changes on board highlights the fact that the management of waste is an ecological problem rather than simply a soil or engineering one.

Waste as an end and a beginning

Dictionary definitions of "waste" abound, but our concern is with unwanted matter or material left after use or otherwise lost (Hawkins 2006; Scanlan 2005). From the traditional archaeological perspective, discarded or lost objects or materials are "out of sight" in that they require excavation. When recovered, however, they are identified no longer as something discarded or lost but instead as something "found." What was waste long ago receives a new life in artefact classification according to material, function or form. From the original object to its remains, the time that we attribute to the trajectory of decay creates renewed value in its passing.

From our less-than-traditional point of view, decay and time play even greater roles as regards their effects on objects and materials from the past, because what is discarded, left, lost, buried or excreted can lose discreteness and become part of the *matrix* of a find rather than the find itself. The relationship between humans and waste in this perspective is so deeply marked by time that few would recognise the matrix as ever having been waste at all. Instead, what was once refuse, human excrement, an abandoned house or a body looks like soil. Waste in this circumstance is both an end (what people disposed of) and a beginning (a growth medium for plants and trees) with time as the powerful vector of transformation. Yet, "disconnect" rather than transition or mutability characterises our thinking regarding ends and beginnings, disposal and generation, discard and production. Strasser (1999, 108–9) characterises this disconnect as a social and historical product of the twentieth century, by which time "waste" had come to refer to material destined for disposal (by the city or the municipality) as a process entirely distinct from production, consumption and use. Scanlan (2005) implies that we do, in fact, make the connection between waste and what becomes of it (as well as what becomes of us), but on a subliminal level; as a result, we separate ourselves from waste (or "garbage" in Scanlan's terms) because waste serves "as a stark reminder of what we really are" (Scanlan 2005, 12). Separation from waste is reinforced further by our commodity culture (Benjamin 1999 and Buck-Morss 1991 as cited in Hawkins 2006, 129), which acts to deny the inevitability of organic change (ageing, decay) through "the cult of the new and the worship of youth" (Hawkins 2006, 129). That organic change via decay and time connects ends to beginnings is the thrust of our chapter. We are building on Hawkins's (2006, 123–8) and Phillips's (1999) model/metaphor of the earthworm and its transformative activity—"fundamental to the making and remaking of the world" (Hawkins 2006, 124)—by returning to the subject of the soil.

Digging up dirt

When we seek to determine why the debris and waste from human activity have not been studied for their contributions to soil building or soil-enhancing properties, several thoughts come to mind. The first is that the term "waste" itself reflects a lack of interest in—and the maintenance of distance from—whatever we discard or excrete (Douglas 2002). When we throw something away, we follow it at most to the trash bin outside our house or building. At that point, most people do not want to know where rubbish piles up or how it is treated. Conveniently, rubbish is carried away in trucks, and faeces and urine are flushed down wastepipes or deposited at a distance from household activity. Waste is something to be whisked away, buried or sealed and, most important, forgotten.

Archaeologists should have cottoned on to the importance of waste—beyond artefacts—long ago, because they have to *dig* to find things. Bits and pieces of objects from past centuries or millennia are not normally lying around on the surface, except in some caves or when brought to the surface by root or animal action. The fact that things get buried is taken for granted rather than questioned. "Backdirt" or "loose" dirt rather than "soil" are the terms used by archaeologists to refer to what is dug up and carried away in buckets or wheelbarrows to reveal material remains. This practice makes clear that "dirt" has a particular connotation—something to "keep out of sight, out of mind" (Montgomery 2008, 2). "Soil" has higher status as a term. When not carried off as "dirt," soil can be studied for its strata or for its cultural/environmental material content; but such studies are directed at what we can learn about the past, not the present.

The past over the present

Archaeologists focus on what people have accomplished in the past. The discipline developed around the recovery of the remnants of the past: tools, ceramics, houses, monumental architecture, burial accompaniments, and the dead, either whole or in parts. Skeletons are studied for burial patterns, for evidence of diet or disease, isotopes or radiocarbon dating. Soils and sediments are put through sieves, or cores are taken for macro- or micro-botanical remains, which can, when identified, provide us with evidence about the composition of the past environment, or what people were eating or growing. The decay of tools, architecture, or cadavers is to be lamented as "poor preservation." Granted that decay processes lie at the core of taphonomic studies, which evaluate the extent to which decomposition affects organisms after death (Blau 2014). Animal, plant and human remains form the core of taphonomic studies, although artefacts are sometimes included. Taphonomic data are utilised, however, to enhance recovery of information about human activity in the past but not to help determine how the decaying remains of human activity have contributed to the character of the developing soil matrix; and it is the soil matrix that has implications for modern agriculture.

Another reason why the decay products of human activities have not been a subject of study is a critical theme of this volume: time. Once decayed, the constituents of decay are not recognised as anything other than natural in origin. The biblical phrase "dust to dust" comes to mind (Genesis 3:19 KJV). If enough time passes and a building or a body disintegrates, it loses its identity. There are techniques, such as chemical testing or soil micromorphology, that can detect the former presence of a building or a body. Phosphorous testing has been used, for example, to detect the possible presence of ancient markets (Coronel et al. 2015; Dahlin et al. 2007), but the aim of the exercise is to learn more about the people of the past. The contribution of phosphorous to the character of the surface soil that has subsequently formed, the long-term effects on soil microbial communities and the consequences for nutrient retention, or the length of time involved for post-occupational strata to accumulate are not matters on which archaeologists or soil scientists have traditionally focused. The exception is studies of the Amazonian *terra preta* or "dark earths" (Arroyo-Kalin 2014; Glaser and Woods 2004). Amazonian dark earth studies tend, however, to be concerned with dark earths as a reflection of Precolumbian Indigenous people's manipulation of the environment. In our case, although Precolumbian practices are of interest, our focus is less on identifying practices and more on qualifying and quantifying the waste and decay of what the practices produced.

Nature over culture

If we leave humans aside for the moment, soil science recognises that soils derive partly from the denudation of rocks and partly from the decomposition of plants and animals (Schaetzl and Thompson 2015, 8) through processes, both real and metaphorical, of "wearing, decay, transience and dissolution" (Viney 2014, 3). Thus soil, like waste, is "an acknowledgement of time's passing" and makes time an "explicit, tangible thing of thought" (Viney 2014, 3). At a more mundane level, the temporality of soil formation—"how fast does soil grow?" (Stockmann, Minasny and McBratney 2014, 48)—has been one of the more difficult issues for soil scientists to tackle since the study of pedogenesis (soil formation) began (Jenny 1941).

Although water covers two-thirds of Planet Earth, the Germanic-language origins of the word "earth" reference the ground or land in some way, and not the sea. Perhaps the bias towards earth is not surprising, since humans are a land-dwelling species and are greatly if not wholly reliant on the earth's soils for sustenance. Despite this essential link between soils and humankind, the pioneers of soil science did not seek to elucidate the nexus between humans and soils. Instead, the founders of the discipline aimed to "conside[r] the soil purely as a natural body," overtly declaring that the science should have "little regard for its practical utilization" (Lyon and Buckman 1946, 1). A century on, it is now unquestionably clear that soils are, and have always been, a fundamental global resource that plays a key role in alleviating many of the burgeoning pressures that confront society: food, water and energy security, the abatement of climate change, the safeguarding of ecosystem diversity and the protection of human health (McBratney, Field and Koch 2014). Soil science has today become an applied science and, as Richter (2007, 8) suggests, one that should embrace "all of the human relations with soils and the global environment." Human relations with soils, however, are deteriorating. In many areas of the world, soils are degrading owing to human activities, and accelerated erosion, compaction, pollution and contamination are truncating the soil's longevity.

The role of humans is absent in the five factors of soil formation: climate, organisms, relief, parent material and time (Schaetzl and Thompson 2015, 283–93). Amundson and Jenny (1991) suggest that human influence is encapsulated within the organism factor. Others have argued that humans have the capacity to alter all five factors of soil formation (Bidwell and Hole 1965). Human capacity to accelerate or retard processes within the soil system by changing soil micro- and meso-climates is well established, as are the effects of removing native vegetation in favour of crop production, re-configuring hillslopes to terraces and accelerating the weathering of parent material through fertiliser use. For all of these examples, the emphasis is on how human activity *affects* soil development (Capra et al., 2015; Schaetzl and Thompson 2015, 6). In other words, the soil mass under study has derived from natural processes (from alluvium and colluvium to glacial till and weathered bedrock), and human activity has only modified its biological, chemical, physical and hydrological make-up.

Soil science recognises that in addition to acting as modifiers of soil, humans can contribute to soil formation by adding materials. *Plaggen* soils—a man-made soil using heather and manure—produced in several European countries (Blume and Leinweber 2004) bear out that extraneous materials can be added to thicken existing soil profiles, although there is great variation worldwide concerning the types of material deposited, the methods and rates of deposition and the justification for these additions (Giani, Makowsky and Mueller 2014). In northeast Scotland, the addition of turves, dung, midden material, calcareous sand and seaweed, or a combination thereof, contributed to a gradual increase in the depth of soil surface and sub-surface layers (Davidson and Simpson 1984). Accumulation rates are believed to have reached 1.9 cm yr^{-1} (Davidson, Harkness and Simpson 1986), giving rise to mounds of up to 4.3 metres in thickness. In the Netherlands, similar practices led to soils thickening up to 1.3 mm yr^{-1} (de Bakker 1979).

Conry (1974) suggests four objectives that justify the historical adoption of plaggen agriculture, of which replenishing nutrients and improving soil physical properties are two. Giani and colleagues (2014) diversify the objectives, citing enhancements to soil health such as greater living space for fauna, enhanced buffer for contaminants and greater carbon store. Denevan and Turner (1974) suggest, in addition, that thickening soil profiles allows easier and deeper root growth and expansion. The motivations behind plaggen agriculture are, therefore, diverse and require an explicit examination of local context. There is, however, one common denominator, which is that additions were made to *existing* soil profiles in order to enhance soil quality and productivity. Here, we propose that human-made products in the form of waste and discard can contribute to the process of pedogenesis itself.

The research at Marco Gonzalez

Our research is focused on a Maya archaeological site, called "Marco Gonzalez," situated on a coral island or "caye" off the coast of Belize (Aimers et al. 2016; Emery and Graham 2003; Graham 1989; Graham and Pendergast 1989; Simmons and Graham 2016; Stemp and Graham 2006; Williams, White and Longstaffe 2009) (see Figures 10.1 and 10.2).

The soils at Marco Gonzalez present a conundrum for traditional soil science. The enigma is palpably clear when one inspects the underlying bedrock: pleistocene limestone with dissolution features (caves and sinkholes), well-developed karst and a thin layer of unconsolidated carbonate sediments (Dunn and Mazzullo 1993). Carbonaceous bedrock—limestone, in particular—is often associated with very thin residual soil because the weathered material is either soluble in water or insoluble and washed off rock into fissures, joints and caves (Schaetzl and Thompson 2015, 19). The soils at Marco Gonzalez, on the contrary, are up to three metres thick (see Figure 10.3).

What are the parent materials from which such relatively thick soils formed?

The remains of human activities at Marco Gonzalez stretch over a period of about 2,000 years and comprise domestic rubbish, abandoned houses, human excreta, human burials, fish and animal bones, tools, construction material, and household and industrial products and their debris (see Table 10.1). Archaeological investigations in 2013–14, sponsored by the Leverhulme Trust (Graham et al. 2017; Macphail et al. 2017), point to these remains as potential parent materials. The constituents of the discarded materials and waste products are those defined by science, such as quartz or iron or calcium carbonate (Aimers et al. 2016; Pope 2018). They occur, however, in products (artefacts) either made by humans (e.g., pottery, plasters and stuccos, building materials, clothing, adornments, paper products) or used and concentrated by them (e.g., shell, bone, stone). Material remains (ecofacts) are also present owing either to human transport—as in the case of bones discarded as fish were prepared for salt preservation and export—or to what people chose to eat and drink. As artefacts, ecofacts, and buried cadavers decay, the constituents enter the soil or sediment matrix and are available to contribute to soil formation. There are several interesting implications. One is that people can have transported the products or their components very long distances from the sources of raw materials, and hence, through decay processes, minerals become deposited far from where they occur naturally. Another is that the chemistry and mineralogy of the deposits will reflect, to a significant degree, human cultural actions and choices.

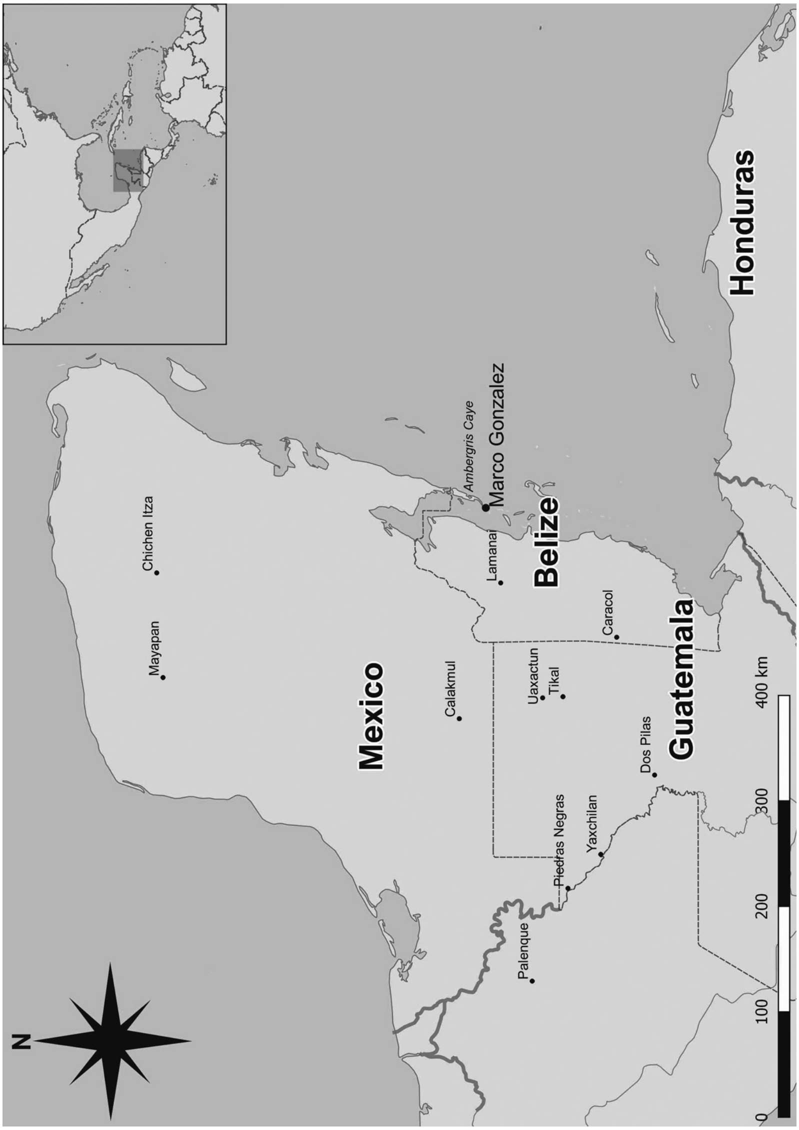

Figure 10.1 Map of Belize showing location of Ambergris Caye and Marco Gonzalez.

Source: Map drawn by Panos Kratimenos.

Figure 10.2 Marco Gonzalez from the air.
Source: Elizabeth Graham.

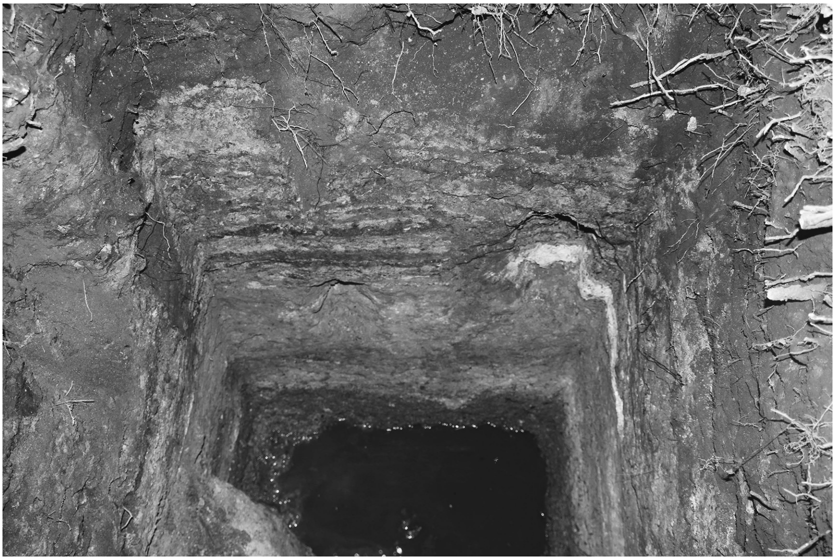

Figure 10.3 Soil profile, Marco Gonzalez.

Source: Elizabeth Graham.

Table 10.1 Marco Gonzalez chronology

Belize Chronology Dated evidence to date from MG is shaded	
Period	*Time*
Modern	*1981–present*
Late British colonial	*1964–1981*
British colonial	*1862–1964*
Early British colonial	*1660s–1862*
Late Spanish colonial	*1648–1708*
Early Spanish colonial	*1544–1648*
Terminal Postclassic	*1492–1544*
Late Postclassic	*1350–1492*
Middle Postclassic	*1200/1250–1350*
Early Postclassic	*960/1000–1200/1250*
Terminal Classic	*750/800–960/1000*
Late Classic	*600–750/800*
Early Classic	*250–600*
Terminal Preclassic	*ad 1–250*
Late Preclassic	*300 bc–ad 1*
Middle Preclassic	*600–300 bc*

Source: Elizabeth Graham.

A third implication is that the conditions generated by hundreds of years of human occupation will be reflected in a particular ecology—animal and plant communities that have adapted to and benefited from human activities (Glanville-Wallis 2015) and have in turn contributed to sediment and soil characteristics.

Although its soils, and the vegetation they support, distinguish Marco Gonzalez from its surroundings, the site is only one of many on Ambergris Caye (Guderjan 1995; Guderjan and Garber 1995; Simmons et al. 2018) that exhibit modern surface soils with higher fertility than is characteristic of soils that form naturally over reef stone (Graham 1998, 2006). Of primary interest is the considerable depth of the deposits revealed in the stratigraphic profile. What the profile represents is not simply soil enrichment but a kind of soil production that would not have occurred had people not lived, littered and died here over centuries. The implication, somewhat contrary to the dicta of the circular economy (Ellen MacArthur Foundation 2017) or environmental advocacy, is that discard and the creation of waste should be considered a key behaviour of potentially sustainable practices.

Impact

Our discussion thus far has been about our hypothesis that degradation and decomposition of waste contribute to sedimentary material and increased soil mass. The time depth entailed in this sort of transformation can be considerable: decades at least, but more probably centuries. The disposal of waste in our short lifetimes—the acts by which we place once-useful things or substances out of sight and mind—nonetheless has environmental impacts that are important to consider. Shorter-term degradative effects that accompany long-term environmental enhancements must be addressed, because waste materials become an intrinsic part of an on-site ecosystem by contributing to the chemical, physical and biological nature of the locale.

How do we determine the relationship between the legacy of waste disposal and the on-site ecosystem? Methods already exist that are used for modern environmental impact assessments (e.g., Ivanova et al. 2015; Nahvi et al. 2018). Our interests and our pilot study at Marco Gonzalez differ in key ways, however, from attempting to determine, for example, the impact of mining waste. In the Marco Gonzalez case, the impact is observable: the modern presence of dark earth and a deep profile, with soils that are commonly dug up by local residents and transported to their gardens. In this circumstance, the question is not "What will the impact be?" but "How did the impact come about?" The field research at the site in 2013–14 was directed at recovering data that would enable us to characterise the nature of the deposits through time to determine their contribution to the constituents of the modern surface and sub-surface soils. No study such as ours has been attempted before, and we had no model to follow. It turned out that archaeological recovery methods, most of which require either hand extraction or fine sieving, were not sufficient to identify the full suite of potential constituents. Nonetheless, through detailed analyses of the fractions from sieving and flotation (Duncan 2019), examination of sediment cores and interpretation of thin sections taken from soil profile column samples, we were able to identify the remains and residues of a number of activities that contributed to the chemistry, mineralogy and soil mass at the site (Graham et al. 2017). What appears to the naked eye to be soil or sediment reflects multiple floors, refuse stamped into surfaces, quartz sand that was once pottery temper and massive deposits of ash and carbon resulting from the heating of brine in vessels to drive off water as part of salt processing (Macphail et al. 2017). Additionally, among the Precolumbian Maya, sub-floor burials were a common practice, and their decay and decomposition, especially from the late eighth through early tenth century, seem to have contributed greatly to the character of the soils that bury the salt processing debris.

LCA (Life Cycle Assessment) was identified as a potential analytical tool for Marco Gonzalez because it is materials-led. Although our ultimate goal is tracking what produced modern soil conditions, our first step was to investigate the shorter-term degradative effects from past waste disposal. LCA is applied widely outside of archaeology to create decision-support tools and to contribute to planning and policy (European Environment Agency 1998, 29). It examines the entire life cycle of a product as a system, and accounts for and quantifies all inputs (products, materials or energy that enter a system, including raw materials) (ISO 2006a, 3–4), outputs (products, materials or energy that leave a process) (ISO 2006a, 4), and interior transfers of raw materials, products and energy (ISO 2006a, 4). The method requires, as we have learned since the 2013–14 field season, a high level of quantification that is best achieved with integration in the planning stages of fieldwork. Although our recovery methods were not sufficient to produce the necessary level of quantification, we nevertheless performed a preliminary LCA using data sourced from the excavations, whereby the product was waste, and outputs were defined as emissions from waste degradation.

The results suggested that the Early Classic period—with mixed domestic and salt production evidence—was a potentially large contributor to short-term ecosystem degradation (Duncan 2019), but it will be necessary in future to develop more specific on-site models for the LCA based on our understanding of the decay and deposition conditions. An understanding of impact scale can be achieved with increased sampling across the site area, and the inclusion of the quantification requirements of LCA into fieldwork strategies, so that data are available across the deposits for different scales and datasets.

Conclusions

The synergies between archaeology and soil science and environmental engineering offer a unique perspective on the long-term legacy of waste and human discard behaviours. An archaeological site on a coral island in Belize may seem an odd platform from which to study the transformation from waste to soil, but there are good reasons for the choice of site. On a coral island, natural soil parent materials are limited to calcium carbonate, and it is easier than it is on the mainland to identify exotic constituents. The humid tropics are environments in which decay of materials that seem "permanent" in temperate climes can be more readily observed. People living in the tropics are aware of the effects of decay processes in their own lifetimes, whereas in temperate or dry climates, decay, particularly of the built environment, is "out of mind." The humid tropics therefore act as a kind of laboratory. It is also true that the lack of the grazing animal complex in the Neotropics may have created optimum conditions for soil building, perhaps as concomitants of a largely vegetable-based indigenous diet and a significant dependence on trees and forest products. Not least, the Maya area offers a long and well-documented occupation history with a refined chronology, which should help to answer the question of how fast the soils grow. Thus, in this setting, contemporary challenges that are very much in our sights and on our minds, such as food and water security or global land degradation, may best be met by considering the temporalities of what we so often keep out of sight and out of mind: waste.

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