nature plants

REVIEW ARTICLE
PUBLISHED: 3 AUGUST 2017 | VOLUME: 3 | ARTICLE NUMBER: 17093

The deep human prehistory of global tropical forests and its relevance for modern conservation

Patrick Roberts[1]*, Chris Hunt[2], Manuel Arroyo-Kalin[3], Damian Evans[4] and Nicole Boivin[1]

Significant human impacts on tropical forests have been considered the preserve of recent societies, linked to large-scale deforestation, extensive and intensive agriculture, resource mining, livestock grazing and urban settlement. Cumulative archaeological evidence now demonstrates, however, that *Homo sapiens* has actively manipulated tropical forest ecologies for at least 45,000 years. It is clear that these millennia of impacts need to be taken into account when studying and conserving tropical forest ecosystems today. Nevertheless, archaeology has so far provided only limited practical insight into contemporary human–tropical forest interactions. Here, we review significant archaeological evidence for the impacts of past hunter-gatherers, agriculturalists and urban settlements on global tropical forests. We compare the challenges faced, as well as the solutions adopted, by these groups with those confronting present-day societies, which also rely on tropical forests for a variety of ecosystem services. We emphasize archaeology's importance not only in promoting natural and cultural heritage in tropical forests, but also in taking an active role to inform modern conservation and policy-making.

By 2050, it is estimated that over half of the world's population will live in the tropics, with many people relying on tropical forests as a source of freshwater and agricultural and urban land, as well as timber, medicine and food[1]. The expansion of human populations into tropical forest environments has seen them become some of the most threatened ecosystems in the world[2,3]. Every day, *c.* 320 km^2 of tropical rainforest is destroyed, significantly impacting human populations, along with 135 plant, animal and insect species[4]. The ongoing viability of dry tropical forests is also under serious threat[5]. These alterations affect ecosystems that are central to the stability of Earth's atmosphere and climate[6], as well as key providers of economic goods and ecosystem services[2].

Focus on recent impacts to tropical forests has tended to promote these ecosystems as pristine and relatively untouched until recent centuries or even decades. Nevertheless, cumulative archaeological interest, spurred on by the application of novel methods of site discovery[7], archaeological science research (for example, refs 8–11) and palaeoenvironmental reconstruction (for example, refs 12,13), have increasingly demonstrated tropical forests to be dynamic 'artefacts' of millennia of human–forest interaction[14,15]. Attempts to investigate the relationship between, on the one hand, prehistoric fire regime alteration, cultivation[16], extensive sedentary settlement and enduring landscape modification[17,18], and, on the other, sustainable past subsistence, water-use and intensive human occupation, have so far been limited. This is despite recent calls from UNESCO[19] and a broad range of researchers[20,21] to actively involve archaeologists in conservation and policy-making in tropical forests.

Awareness of long-term anthropogenic impacts to tropical forests has only gradually emerged. As recently as the 1980s and 1990s, anthropologists argued that tropical forests were unattractive environments for human occupation (for example, ref. 22). This view was further promoted by archaeologists, who, for example, saw tropical forests as barriers to the expansion of Late Pleistocene *Homo sapiens* foragers[23], and also deemed them incapable of supporting agricultural populations[24]. This bias has been exacerbated by the generally poor preservation of organic archaeological remains in tropical forest environments (for example, ref. 25). Accordingly, scholarly assumptions about the timing of significant anthropogenic impacts on tropical forests generally point to the post-industrial era or, at the earliest, the colonial era of European 'discovery'[26,27]. Clearly, the accumulating database of archaeological and palaeoecological evidence for pre-industrial and pre-colonial tropical forest occupation and transformation has not been effectively communicated beyond a restricted set of sub-disciplines (though see refs 28–31). As a consequence, this evidence has only played a small role in discussions about the start date or characteristics of the Anthropocene (for example, ref. 32, but see ref. 33).

Here, we review evidence that has accumulated, primarily in recent decades, for the long-term human transformation of tropical forest ecosystems. Our review is not exhaustive, but rather seeks to highlight how recent studies, drawing on a suite of new archaeological science and palaeoecological methods, have dramatically altered understanding of tropical forest prehistories and histories globally. We focus on three modes of human impact that, over the long-term, stack up as broad but non-synchronous phases: a phase marked by deliberate forest burning, species translocation and management of forest biota; a phase of agricultural cultivation and enduring landscape modification; and a phase of urban occupation and transformation of tropical forests. As will be seen, these modes are not mutually exclusive. We conclude by examining the implications of new archaeological and palaeoecological perspectives on the long-term prehistory of tropical forests for contemporary agendas of conservation, management, and resilience building.

Early impacts

In the last ten years, the archaeologically acknowledged human inhabitation of tropical forests has quadrupled in age. There is now clear evidence for the use of tropical forests by our species in Borneo[12,13,34] and Melanesia[35] by *c.* 45 ka, in South Asia by *c.* 36 ka[36], and in South America by *c.* 13 ka[37]. There are suggestions of earlier rainforest occupation *c.* 125 ka in Java[38,39], *c.* 60 ka in the Philippines[40], *c.* 100 ka in China[41], and in Africa, perhaps from the

[1]Max Planck Institute for the Science of Human History, 07745 Jena, Germany. [2]Liverpool John Moores University, Liverpool L3 3AF, UK. [3]University College London, London WC1H 0PY, UK. [4]École française d'Extrême-Orient, 75116 Paris, France. *e-mail: roberts@shh.mpg.de

first appearance of *H. sapiens*, *c.* 200 ka[42], though further research is required to verify these cases[43] (note 'ka' represents thousands of calibrated/uncalibrated years ago; where this refers to radiocarbon dates it is equivalent to calibrated years BP). Early modern humans adapted to diverse tropical forest formations, ranging from the subzero temperatures of montane forests to dense, humid, evergreen rainforests, undertaking sophisticated forest mammal hunting and plant processing (for example, ref. 44). Moreover, people did not just adapt passively to these environments, but from the onset modified them in fundamental ways[10,45], with outcomes that have affected the natural histories of these forests to the present day.

In Southeast Asia, mounting evidence points to deliberate anthropogenic biomass burning in order to create forest-edge habitats from the first human arrival *c.* 45 ka[13,35] (Fig. 1). This may reflect reliance on starchy forest-edge plants and bearded pigs that were attracted to canopy openings[12]. In tropical Australia, the decline of *Araucaria* and rise of Eucalypts and *Casuarina* have been correlated with the advent of anthropogenic biomass burning after 40 ka[46–48]. Human landscape impacts have also been documented in the montane tropical forests of the New Guinea Highlands from 45–35 ka, even retarding vegetation re-colonization in the region following the Last Glacial Maximum[49]. That early foragers could have played a significant role in reshaping newly colonized landscapes is also supported by evidence that later foragers did. For example, the first colonists of the eastern Caribbean in the mid-Holocene brought their foraging, collecting and hunting lifestyles with them, and engaged in modification and management of tropical ecosystems that is reflected in significant shifts in pollen and phytolith datasets[50].

Still debated, but potentially even more significant in terms of long-term impact, is human involvement in Late Pleistocene tropical forest megafaunal extinctions, which are argued to have had anthropogenic, climatic or multivariate causes, and to have resulted in major changes to ecosystem structure[47]. While discussions of megafaunal extinctions in tropical forests have been relatively limited, these environments possessed diverse megafauna, some of which persists in parts of Africa and Asia[51]. In the New Guinea Highlands there is evidence for megafauna, including extinct marsupials (such as *Maokopia ronaldii* and *Thylogale hopeii*), at West Balim River *c.* 30 ka and at Nombe *c.* 25 ka, with their gradual demise occurring after human arrival and subsequent biomass burning[49,52]. In the Amazon basin, megafaunal extinctions, such as those of large mastodons (*Haplomastodon waringi*) and ground sloths (*Eremotherium laurillardi*), significantly altered biodiversity, vegetation distributions, nutrient cycling and carbon storage in the region, with effects persisting to the present day[53], though the role of humans in this process has yet to be fully explored (for example, ref. 54).

Tropical forest foragers also reshaped landscapes through the active long-distance translocation of species. In Melanesia, people translocated small mammals for reliable protein from 20 ka[55]. The result is that species such as bandicoot (*Perameles* sp.) and cuscus (*Phalanger* sp.) are now widely distributed across Melanesian islands, including the Bismarck Archipelago, where they are not endemic. Yams (*Dioscorea alata*) are present on both sides of Wallace's Line by 45 ka[34,56]. By the terminal Pleistocene or early Holocene, a web of translocations seems to have carried economically important plants, including the sago palm (*Metroxylon sagu*), yams (*D. alata*) and *Dioscorea hispida*, taro (*Colocasia esculenta*) and swamp taro (*Alocasia longiloba*), to the coastlands and islands of Southeast Asia, the Philippines and Wallacea, and possibly also into North Australia[57–59] (Fig. 1). Modification of the distribution and density of edible and economic tree species has also been observed among Amazonian hunter-gatherers[60].

Farming in the forest

The montane rainforests of New Guinea provide some of the earliest evidence for agricultural experimentation anywhere in the world[8,58]. At Kuk Swamp, terminal Pleistocene human foragers moved and tended tropical plants such as yam (*Dioscorea* sp.), banana (*Musa* spp.) and taro (*Colocasia* sp.) until these species were fully 'domesticated' by the early–mid Holocene[8,61]. Both recent and ancient agricultural practices in this and other tropical forest regions were, however, combined with hunting/fishing and gathering. For example, while there was large-scale land management at Kuk Swamp, other surrounding sites demonstrate continued evidence for small mammal hunting[62,63]. Studies of early human activities in rainforest environments have helped to blur the boundaries between tropical forest hunter-gatherers and farmers, revealing sophisticated subsistence practices, such as transplantation and cultivation extending back to at least the early Holocene. Such studies highlight how even these small populations may have altered tropical forest environments (Fig. 2).

The eventual domestication of tropical forest plants and animals, together with the incorporation of plants and animals domesticated outside of tropical forest environments, and the emergence of agricultural systems, reflect new thresholds in the intensifying relationship between humans and tropical forest environments. The scale of human selection on tropical forest species can be seen in the number of them that are central to global cuisine today, including sweet potato, manioc, chilli, black pepper, mango, yams, pineapple and banana[64] (Fig. 3). While domesticated tropical forest fauna are fewer in number, the now globally distributed domestic chicken also most probably had a tropical forest origin in the form of the jungle fowl[65]. Despite new crops, however, increasingly settled tropical forest communities also continued to practice the same agroforestry systems developed by their forebearers, with a focus on the management of various tree species. For example, the first Polynesian occupants of the Chatham Islands brought with them translocated tree crops, which were important to arboriculture and agroforestry strategies (with lasting impacts on conservation efforts in these islands)[66]. Likewise, stands of Brazil nut (*Bertholletia excelsa*) in the Amazon closely map onto ancient human settlements[67], reflecting long-term human interaction with and management of this species.

In addition to species domestication and translocation, the development of indigenous tropical forest agricultures during the Holocene also led to the intensive drainage and modification of soils. We have already mentioned the distinctive aspects of early Holocene indigenous agriculture in Melanesia, which involved the formation of drainage ditches to prevent waterlogging of soils in planting areas[61]. In Amazonia, evidence from the Llanos de Mojos[68] and Guyanas[69] highlights how populations adapted to flooding conditions in order to intensify agricultural production. In areas now dominated by tropical rainforest, pre-Columbian settlement and fire-intensive land-use practices resulted in the formation of expanses of fertile anthropic soils (Fig. 2) known as *terras pretas* and *terras mulatas*[10,17]. These may have been re-utilized as fertile soilscape legacies by populations in the past, just as they are employed in the present.

Over their human history, tropical forests have also been influenced by expansions of neighbouring farming groups and crops. In Amazonia, the adoption of Mesoamerican maize (*Zea mays*) dates back to at least 6,000 years BP[70], and the plant was an important part of regional diets by the late Holocene[71]. In Africa, Bantu agriculturalists farming pearl millet and cattle appear to have expanded into the tropical rainforests of western and central Africa, *c.* 2.5 ka, when their extent was greatly contracted[24]. This expansion is suggested to have resulted in severe erosion and forest fragmentation in eastern and central Africa[72]. Similarly, the arrival of rice and millet agriculture in the tropical forests of Southeast Asia is associated with large-scale forest clearance, particularly within the more deciduous forests to the north of the equatorial belt in mainland Southeast Asia, which would have been easier to burn[73,74].

Figure 1 | Tropical Australasian Pleistocene and Holocene sites with evidence for human presence, forest disturbance and plant translocation. Tropical Australasia showing Pleistocene sites with reasonably certain modern human presence, Pleistocene and Holocene vegetation disturbance by fire atypical of the longer Pleistocene record, or where humans are directly implicated, and locations with evidence for economically useful plants found both sides of the biogeographical discontinuity of Wallace's Line. Top: late Pleistocene; bottom: early Holocene 11,000–5,000 BP. The figure is compiled based on data from Barker *et al.*[118], Denham[58], Hunt *et al.*[13], Hunt and Premathilake[59], Hunt and Rabett[119], Marwick *et al.*[120], Mijares *et al.*[40], Moss and Kershaw[47], Paz[56], Kershaw *et al.*[121], van der Kaars *et al.*[122], Storm *et al.*[38], Summerhayes *et al.*[35] and Westaway *et al.*[39]

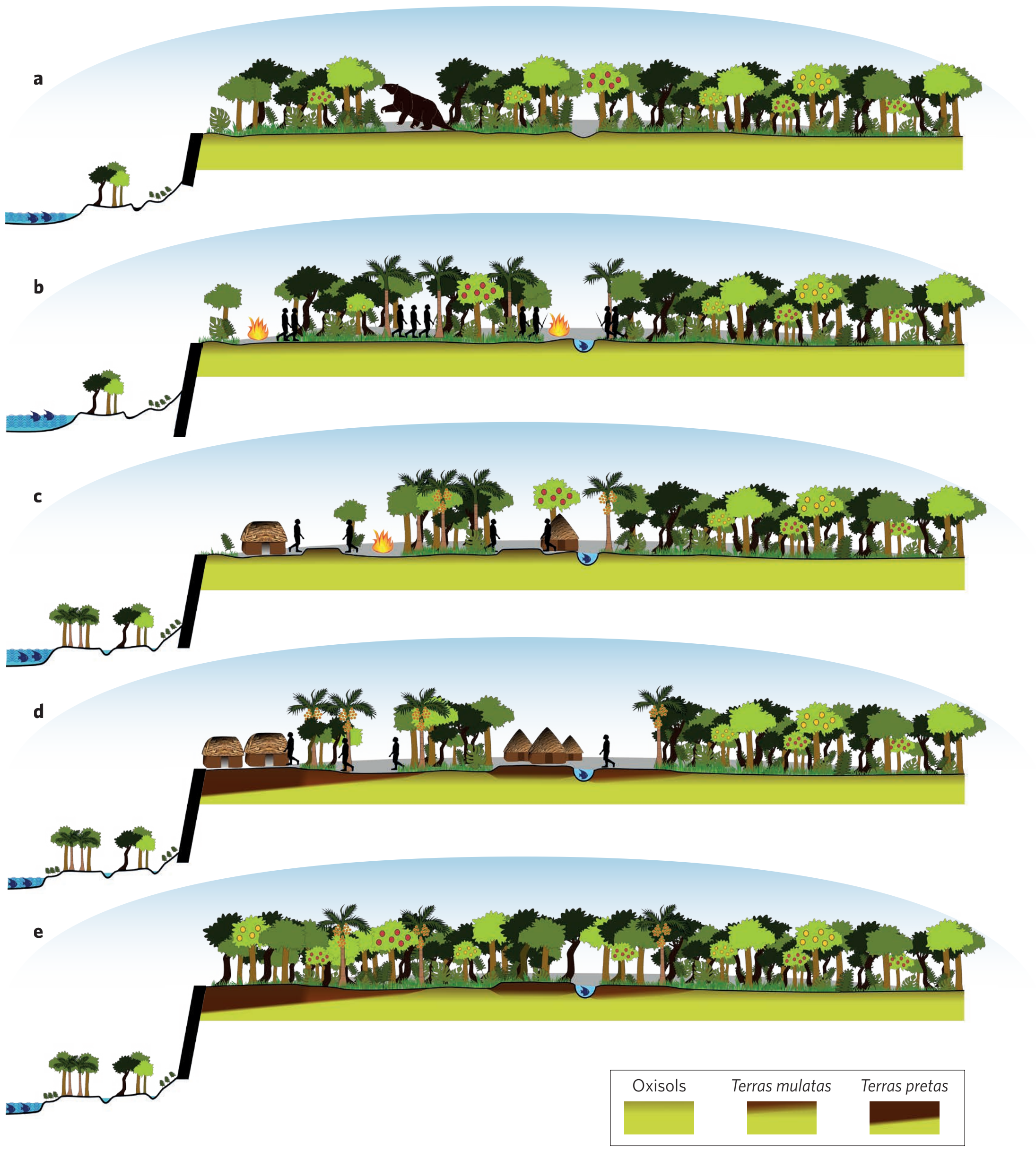

Figure 2 | A model of anthropic impact on tropical forest environments based on Amazonia. a, Pre-human tropical forest with natural gap dynamics, including megafaunal impacts. **b**, Nomadic foraging groups utilizing plant (including tree) and animal resources and, where desirable, forming gaps through forest burning. **c**, Initial sedentism with house gardens and slight soil modification. **d**, Increased sedentism and population growth with corresponding soil modification, swidden plots, slash and burn impacts, and small regrowth of trees on old plots. **e**, Abandonment leading to forest regrowth and the legacy of anthropic soils. Note the central role played by aquatic resources and alluvial environments for the selection of appropriate environments for human inhabitation.

In the Caribbean archaic and ceramic periods, meanwhile, communities brought a variety of exogenous domesticates, including wild avocado (*Persea americana*), manioc (*Manihot esculenta*), dog (*Canis lupus familiaris*) and guinea pig (*Cavia porcellus*), into island tropical forests[75]. Early Polynesians similarly carried a range of domesticated crops, animals, and commensals that have contributed to the alteration of tropical forests across the region[76,77]. On Tonga, for example, tropical forest tree species declined in abundance following Polynesian colonization[78]. Extinctions also ensued. Estimates suggest that avian extinctions from the tropical Pacific after Polynesian colonization and prior to European arrival numbered in the hundreds, if not thousands[79].

Nevertheless, outside of more vulnerable island contexts, the adaptation of non-endemic domesticates to tropical forest environments did not generally result in significant or lasting environmental degradation in pre-industrial times. Indeed, most communities entering these habitats were initially at low population densities and appear to have developed subsistence systems that were tuned to their particular environments. This stands in stark contrast to the more recent effects of industrial monoculture and extensive cattle ranching in tropical forest settings. These practices, which induce rampant clearance, reduce biodiversity, provoke soil erosion and render landscapes more susceptible to the outbreak of wild fires (for example, refs 80,81), represent some of the greatest dangers facing tropical forests. Pre-industrial farming in tropical forests, which often employed fire in controlled fashion (for example, refs 17,82), by contrast, relied on an intimate knowledge of forest dynamics and successful integration within the whole ecological

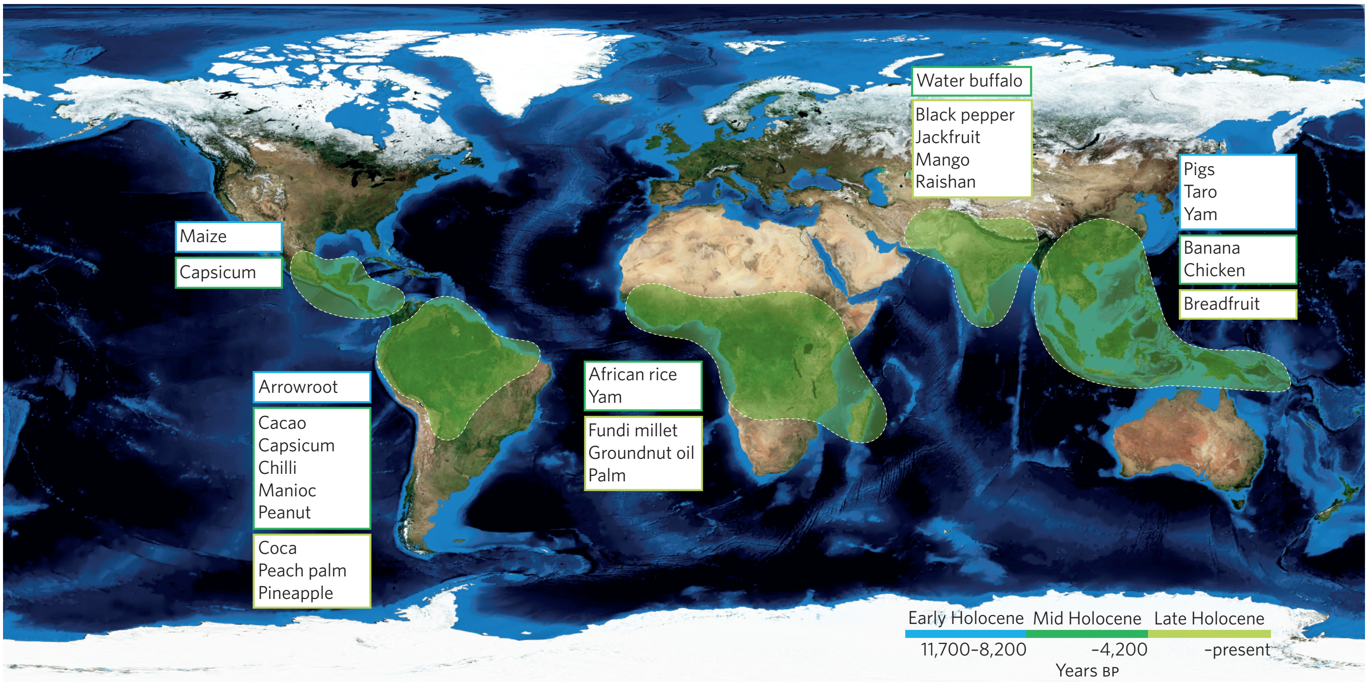

Figure 3 | Map of the temporal and geographical origins of selected domesticated plant and animal resources coming from tropical forest regions during the early (11,000–8,200 ka), middle (8,200–4,200 ka) and late Holocene (4,200 ka onwards). Temporal periods have been defined on the basis of Walker *et al.*[123] Temporal and geographical information comes from Pearsall[124], Clement *et al.*[125], Piperno[126], Denham[58], Kingwell-Banham and Fuller[127], Storey *et al.*[128], Fuller and Hildebrand[129], Hunt and Rabett[119] and Nagarajan *et al.*[130] Image reproduced with permission from Reto Stöckli, NASA Earth Observatory.

system, and largely appears to have encouraged more flexible and resilient farming systems based around polyculture.

Forests of ruins or sustainable urbanism

Public perceptions of archaeology in tropical forests often revolve around 'lost' temples that are only now being 'discovered', with romantic visions of vanished cities abandoned to the jungle[83]. In places such as Cambodia, however, these perceptions are deeply political and firmly grounded in colonialism[84]. Evocative images of the rise, fall, and sudden 'collapse' of societies in these environments also owe much to twentieth century archaeological suggestions that large, permanent settlements could not be maintained due to the low fertility of tropical soils[85]. Nevertheless, over the last two decades, archaeological data, including canopy-penetrating LiDAR (light detection and ranging) mapping, have revealed previously unimagined scales of human settlement in the Americas and Southeast Asia[7,86]. Indeed, extensive settlement networks in the tropical forests of Amazonia, Southeast Asia, and Mesoamerica clearly persisted for much longer than the modern industrial and urban settlements in these environments have currently been present[18,87].

Several challenges face urban populations in tropical forest environments today. For instance, floods and mudslides pose one of the greatest threats to modern urban settlements in tropical settings[88]. In 1999, a high-magnitude storm in the Vargas region of northern Venezuela triggered flash floods and mudslides that killed between 10,000 and 15,000 people and destroyed *c.* 40,000 homes in one of the worst natural disasters in the recorded history of the Americas[88]. Past urban populations clearly acknowledged such challenges and worked to mitigate them. For example, communities in and around the great temple-cities of the Angkor period in Cambodia developed large-scale hydrological infrastructure to both ensure access to water and divert excess flow away from settlements[7] (Fig. 4). Similarly, archaeological evidence from *c.* 1.3 ka in Mesoamerica and Southeast Asia suggests both wetland modification and raised fields were deployed to minimize the impact of flooding on settlements[89,90]. Nevertheless, in some cases, the ongoing danger of this high-water-flow system could not be contained, with disastrous consequences. Such impacts have been observed, for example, in the remains of the settlements of the Khmer Empire, where hydraulic systems ultimately failed[7]. The archaeological record offers both mitigation strategies and cautionary tales.

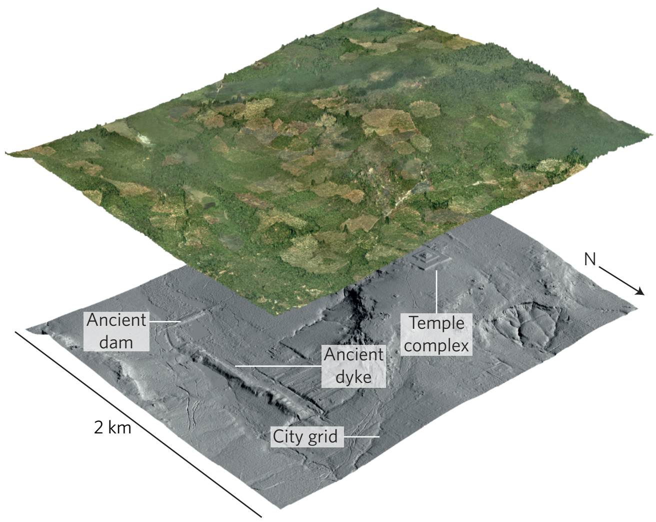

Figure 4 | LiDAR-derived bare earth model of urban and hydraulic infrastructure at a city on Phnom Kulen, ~35 km north of Angkor Wat. Penny *et al.*[131] have demonstrated that the area shown here was subject to intensive land use for several centuries between the eighth and twelfth centuries CE, punctuated by episodes of severe erosion.

Another major challenge to sustaining large populations in tropical forest habitats is the soil erosion that results from forest clearance and large-scale agricultural systems[91,92]. In Mesoamerica, certain Mayan communities appear to have 'gardened' the local forest for their resources rather than practicing forest clearance and monoculture farming[93]. This facilitated the long-term sustainable support of large populations. Southern Mayan cities, or at least their ruling elites, perhaps did over-stretch under duress from climate change, but an overall decrease in population, with perhaps significant effects on the erosive potential of the landscape[91], occurred alongside increased resilience and population growth in the northern Maya region[90,94]. In Amazonia, dense pre-colonial populations relied on various combinations of fire-intensive cultivation practices, raised agricultural fields, capture and management of aquatic riverine resources, and foraging for wild fauna and plants[17,68,95]. This agroforestry system helped produce fertile soils and enhanced long-term forest biodiversity. Deforestation appears to have been sufficiently limited that evidence of significant human-induced erosion in Amazonia is so far scant.

Many other archaeological and palaeoecological intersections demonstrate the fine balance between large human populations and their tropical forest environments. For instance, current evidence would suggest that a tendency towards sprawling was already present in early tropical urbanism[96]. This is mirrored to a significant degree in the modern world and is reflected in concerns about the sustainability of sprawling megacities resulting in continual degradation of environments at the ever-expanding urban fringe[97]. The decline of early, low-density megacities with dense urban cores and massive state-sponsored hydraulic infrastructure often appears to have been strongly correlated with climate change[98,99]. On the other hand, diversification, decentralization and 'agrarian urbanism' seem to have contributed to overall resilience[100,101].

Implications for the twenty-first century

Although tropical forests were once seen as pristine, they are increasingly becoming recognized as outcomes of long-standing human modification, management and transformation. New methods and emerging datasets are demonstrating unequivocally that their enduring transformation by past human populations has much greater antiquity than previously thought. Yet despite the contemporary threat to tropical forests, and the need for concerted cross-disciplinary efforts to address the challenges they face, growing archaeological datasets have to date played only a relatively minor role in shaping contemporary discussions, debate, and policy-making. This is in part a result of limited archaeological survey and exploration of tropical forests relative to other environments. It is also due to the fact that few ecologists and conservationists have engaged with mounting evidence for the long-term human impact of tropical forest environments (however, see refs 15,31,102).

Some important strides have nonetheless been made. Increasing numbers of world heritage sites are now being accepted from tropical forest habitats, ranging from early *H. sapiens* cave sites in Sri Lanka[103] to large-scale field systems in Bolivia[104]. UNESCO[19] is now actively seeking to create joint world heritage sites of natural and cultural importance in tropical forest regions so that archaeological sites and their forest contexts are mutually protected within the framework of the United Nations 2030 Sustainable Development Programme[105]. Ecological restoration projects are also drawing on archaeological data. In the tropical forests of Hawaii, for example, wild flowering plants identified in archaeobotanical assemblages have been successfully reintroduced into regions from which they had been extirpated by the twenty-first century[106].

Ancient tropical forest urban centres are also attracting broader attention in terms of their potential to shed light on contemporary challenges. For example, the extensive urban fringes around many ancient tropical forest urban centres are being drawn upon within present-day urban planning research (for example, ref. 97). The role of such peri-urban interfaces in local resilience, in addressing vulnerability of urban centres to climate change, and in supporting current livelihoods and food security are of increasing interest, with archaeological data from tropical regions providing useful case studies of long-term dynamics[97]. Also of interest have been tropical rainforest anthrosols, such as the fertile *terra preta* soils of the pre-Columbian Amazon. Research into these pre-Columbian soilscape legacies has both encouraged the search for pantropical analogues[107,108] and inspired attempts to recreate similarly fertile soils[109].

Tropical forest archaeology is now past its pioneering stage. Although its development over the past decades has been enabled by new methods within and beyond the discipline of archaeology, the role of deforestation in revealing previously hidden ancient structures underlines the urgency of drawing on the past to inform present-day policy and planning. This urgency is fully felt by indigenous and traditional populations in tropical regions, many of whose livelihoods and cultural existence are intimately linked to tropical forest environments. For instance, Mbuti populations in Central Africa have been gradually evicted from the tropical evergreen rainforests of this region over the last decade or so[110], sometimes in the name of nature conservation. This has led not only to loss of traditional ecological knowledge but also to pervasive malnutrition and disease among some groups[111]. In the Brazilian Amazon, the impact of expanding infrastructure on populations is severe[112] and current debates examine the ethics of contract archaeological work in environmental licencing of large-scale infrastructure projects[113]. Threats to indigenous and traditional populations, their livelihoods, and their knowledge systems are global in scope and need to be factored into any attempts to marry archaeological practice and policy relating to tropical forests.

Archaeological and palaeoecological data relating to ancient tropical forest problematizes the notion of any return to pristine conditions. If past human populations have in many cases altered tropical forests in ways that have rendered them more useable for human inhabitation—improving ecosystem services in modern parlance—then perhaps restoration is a problematic goal, at least if such practices are aimed at restoring to some 'original' condition. Archaeological research instead promotes recognition and, in some cases, conservation of 'novel ecosystems'[114,115] that have helped to sustain human populations over the long term. The championing of novel ecosystems and abandonment of traditional conservation goals are controversial ideas, but are clearly amongst a number of key debates that archaeologists might usefully weigh in on as part of wider, interdisciplinary discussions about tropical forests.

In conclusion, we suggest that emerging understanding of the long-term history of tropical forests points to a number of core recommendations. Foremost amongst these is that indigenous and traditional peoples—whose ancestors' systems of production and knowledge are slowly being decoded by archaeologists—should be seen as part of the solution and not one of the problems of sustainable tropical forest development. Second, there is a need for greater dissemination of the findings of archaeology beyond the discipline in order to enable broader understanding of long-term human alteration of tropical forest regions, and informed consideration of its implications. Third, we should continue to advance along the path of more regular and intensive exchange between archaeologists, ecologists, anthropologists, biologists and geographers, engaging beyond academia with international bodies such as UNESCO and FAO[19–21,116,117]. To this end, we advocate holding further regular meetings dedicated to a holistic and pantropical approach to the study of the archaeology of tropical forest biomes, as well as undertaking to achieve broader engagement between archaeologists and stakeholders.

Received 24 February 2017; accepted 17 May 2017;
published 3 August 2017

References

1. The State of the Topics Project. *State of the Tropics 2016 Report* (James Cook Univ., 2016).
2. Gardner, T. A. *et al.* Prospects for tropical forest biodiversity in a human-modified world. *Ecol. Lett.* **12,** 561–582 (2009).
3. Ghazoul, J. & Shiel, D. *Tropical Rain Forest Ecology, Diversity, and Conservation* (Oxford Univ. Press, 2010).
4. *Measuring the Daily Destruction of the World's Rainforests* (Scientific American, 2009); http://www.scientificamerican.com/article/earth-talks-daily-destruction
5. Banda, K. *et al.* Plant diversity patterns in neotropical dry forests and their conservation implications. *Science* **353,** 1383–1387 (2016).
6. Martin, C. *On the Edge: The State and Fate of the World's Tropical Rainforests (Report to the Club of Rome)* (Greystone Books, 2015).
7. Evans, D. Airborne laser scanning as a method for exploring long-term socio-ecological dynamics in Cambodia. *J. Archaeol. Sci.* **74,** 164–175 (2016).
8. Denham, T. P. *et al.* Origins of agriculture at Kuk Swamp in the highlands of New Guinea. *Science* **301,** 189–193 (2003).
9. Barton, H. The case for rainforest foragers: the starch record at Niah Cave, Sarawak. *Asian Perspect.* **44,** 56–72 (2005).
10. Arroyo-Kalin, M. The Amazonian Formative: crop domestication and anthropogenic soils. *Diversity* **2,** 473–504 (2010).
11. Roberts, P. *et al.* Direct evidence for human reliance on rainforest resources in late Pleistocene Sri Lanka. *Science* **347,** 1246–1249 (2015).
12. Barker, G. *et al.* The 'human revolution' in lowland tropical Southeast Asia: the antiquity and behaviour of anatomically modern humans at Niah Cave (Sarawak, Borneo). *J. Hum. Evol.* **52,** 243–261 (2007).
13. Hunt, C. O., Gilbertson, D. D. & Rushworth, G. A 50,000-year record of late Pleistocene tropical vegetation and human impact in lowland Borneo. *Quat. Sci. Rev.* **37,** 61–80 (2012).
14. Barton, H., Denham, T., Neumann, K. & Arroyo-Kalin, M. Long-term perspectives on human occupation of tropical rainforests: an introductory overview. *Quat. Int.* http://dx.doi.org/10.1016/j.quaint.2011.07.044 (2012).
15. McMichael, C. N. H., Matthews-Bird, F., Farfan-Rios, W. & Feeley, K. J. Ancient human disturbances may be skewing our understanding of Amazonian forests. *Proc. Natl Acad. Sci. USA* **114,** 522–527 (2017).
16. Piperno, D. R. & Pearsall, D. M. *The Origins of Agriculture in the Lowland Neotropics* (Smithsonian Acad. Press, 1998).
17. Arroyo-Kalin, M. Slash-burn-and-churn: landscape history and crop cultivation in pre-Columbian Amazonia. *Quat. Int.* **249,** 4–18 (2012).
18. Heckenberger, M. J. *et al.* Pre-Columbian urbanism, anthropogenic landscapes and the future of the Amazon. *Science* **321,** 1214–1217 (2008).
19. Sanz, N. *Exploring Frameworks for Tropical Forest Conservation: Managing Production and Consumption for Sustainability* (UNESCO, 2017).
20. Babin, D. *Beyond Tropical Deforestation: From Tropical Deforestation to Forest Cover Dynamics and Forest Development* (CIRAD/UNESCO, 2004).
21. De Dapper, M. *Tropical Forests in a Changing Global Context* (ARSOM, 2005).
22. Bailey, R. C. *et al.* Hunting and gathering in tropical rain forest; is it possible? *Am. Anthropol.* **91,** 59–82 (1989).
23. Gamble, C. *Timewalkers: The Prehistory of Global Colonization* (Stroud, Alan Sutton, 1993).
24. Grollemund, R. *et al.* Bantu expansion shows that habitat alters the route and pace of human dispersals. *Proc. Natl Acad. Sci. USA* **112,** 13296–13301 (2015).
25. Stahl, P. W. Archaeology in the lowland American tropics: current analytical methods and recent applications. (Cambridge Univ. Press, 1995).
26. Hemming, J. *Tree of Rivers: The Story of the Amazon* (Thames and Hudson, 2009).
27. Lewis, S. L. & Maslin, M. A. Defining the Anthropocene. *Nature* **519,** 171–180 (2015).
28. Steege, H. t. *et al.* Hyperdominance in the Amazonian tree flora. *Science* **342,** 325 (2013).
29. McMichael, C. *et al.* Predicting pre-Columbian anthropogenic soils in Amazonia. *Proc. R. Soc. Lond. B Biol. Sci.* **281,** 20132475 (2014).
30. Bush, M. B. *et al.* Human disturbance amplifies Amazonian El Niño–Southern Oscillation signal. *Glob. Change Biol.* http://dx.doi.org/10.1111/gcb.13608 (2017).
31. Levis, C. *et al.* Persistent effects of pre-Columbian plant domestication on Amazonian forest composition. *Science* **355,** 925–931 (2017).
32. Smith, B. D. & Zeder, M. A. The onset of the Anthropocene. *Anthropocene* **4,** 8–13 (2013).
33. Roosevelt, A. C. The Amazon and the Anthropocene: 13,000 years of human influence in a tropical rainforest. *Anthropocene* **4,** 69–87 (2013).
34. Barker, G. *Rainforest Foraging and Farming in Island Southeast Asia Vol. 1: The Archaeology of the Niah Caves, Sarawak* (McDonald Institute, 2013).
35. Summerhayes, G. R. *et al.* Human adaptation and plant use in Highland New Guinea 49,000 to 44,000 years ago. *Science* **330,** 78–81 (2010).
36. Perera, N. *et al.* People of the ancient rainforest: late Pleistocene foragers at the Batadomba-lena rockshelter, Sri Lanka. *J. Hum. Evol.* **61,** 254–269 (2011).
37. Roosevelt, A. C., Douglas, J. & Brown, L. in *The First Americans: The Pleistocene Colonization of the New World* (ed. Jablonski, N. G.) 159–223 (California Acad. Sci., 2002).
38. Storm, P. *et al.* Late Pleistocene *Homo sapiens* in a tropical rainforest fauna in East Java. *J. Hum. Evol.* **49,** 536–545 (2005).
39. Westaway, K. E. *et al.* Age and biostratigraphic significance of the Punung rainforest fauna, East Java, Indonesia, and implications for Pongo and Homo. *J. Hum. Evol.* **53,** 709–717 (2007).
40. Mijares, A. S. B. *et al.* New evidence for a 67,000-year-old human presence at Callao Cave, Luzon, Philippines. *J. Hum. Evol.* **59,** 123–132 (2010).
41. Liu, W. *et al.* The earliest unequivocally modern humans in southern China. *Nature* **526,** 696–700 (2015).
42. Mercader, J. Forest people: the role of African rainforests in human evolution and dispersal. *Evol. Anthr.* **11,** 117–124 (2002).
43. Roberts, P., Boivin, N., Lee-Thorp, J., Petraglia, M. & Stock, J. Tropical forests and the genus *Homo*. *Evol. Anthr.* **25,** 306–317 (2016).
44. Barker, G. & Farr, L. *Archaeological Investigations in the Niah Caves, Sarawak Vol. 2.* (McDonald Institute, 2016).
45. Gnecco, C. Against ecological reductionism: late Pleistocene hunter-gatherers in the tropical forests of northern South America. *Quat. Int.* **109–110,** 13–21 (2003).
46. Kershaw, A. P., Bretherton, S. C. & van der Kaars, S. A complete pollen record of the last 230 ka from Lynch's Crater, north-eastern Australia. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* **251,** 23–45 (2007).
47. Moss, P. T. & Kershaw, A. P. A late Quaternary marine palynological record (oxygen isotope stages 1 to 7) for the humid tropics of northeastern Australia based on ODP site 820. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* **251,** 4–22 (2007).
48. Bird, M. I. *et al.* Humans, megafauna and environmental change in tropical Australia. *J. Quat. Sci.* **20,** 493–452 (2013).
49. Fairbairn, A. S., Hope, G. S. & Summerhayes, G. R. Pleistocene occupation of New Guinea's highland and subalpine environments. *World Archaeol.* **38,** 371–386 (2006).
50. Siegel, P. E. *et al.* Paleoenvironmental evidence for first human colonization of the eastern Caribbean. *Quat. Sci. Rev.* **129,** 275–295 (2015).
51. Malhi, Y., Gardner, T. A., Goldsmith, G. R., Silman, M. R. & Zelazowski, P. Tropical forests in the Anthropocene. *Annu. Rev. Environ. Resour.* **39,** 125–159 (2014).
52. Hope, G. S., Flannery, T. F. & Boeardi, N. A preliminary report of changing Quaternary mammal faunas in subalpine New Guinea. *Quat. Res.* **40,** 117–26 (1993).
53. Doughty, C. E. *et al.* Megafauna extinction, tree species range reduction, and carbon storage in Amazonian forests. *Ecography* **39,** 194–203 (2016).
54. Rossetti, D. d. F., de Toledo, P. M., Moraes-Santos, H. M. & de Araújo Santos, A. E. Jr. Reconstructing habitats in central Amazonia using megafauna, sedimentology, radiocarbon, and isotope analyses. *Quat. Res.* **61,** 289–300 (2004).
55. Gosden, C. & Robertson, N. in *Report of the Lapita Homeland Project* (eds. Allen, J. & Gosden, C.) 20–91 (Australian Natl Univ., 1991).
56. Paz, V. J. Rock shelters, caves, and archaeobotany in island Southeast Asia. *Asian Perspectives* **44,** 107–118 (2005).
57. Denham, T. P., Donohue, M. & Booth, S. Revisiting an old hypothesis: horticultural experimental in northern Australia. *Antiquity* **83,** 634–648 (2009).
58. Denham, T. P. Early agriculture and plant domestication in New Guinea and Island Southeast Asia. *Curr. Anthropol.* **52,** S379–S395 (2011).
59. Hunt, C. O. & Premathilake, R. Early Holocene vegetation, human activity and climate from Loagan Bunut, Sarawak, Malaysian Borneo. *Quat. Int.* **249,** 105–119 (2012).
60. Balée, W. Footprints of the forest: Ka'apar ethnobotany—the historical ecology of plant utilization by an Amazonian people. (Columbia Univ. Press, 1994).
61. Golson, J. in *Foraging and Farming: The Evolution of Plant Exploitation* (eds Harris, D. R. & Hillman, G. C.) 109–136 (Unwin Hyman, 1989).
62. Gaffney, D., Ford, A. & Summerhayes, G. R. Crossing the Pleistocene–Holocene transition in the New Guinea Highlands: evidence from the lithic assemblage of Kiowa rockshelter. *J. Anthropol. Archaeol.* **39,** 223–246 (2015).
63. Roberts, P., Gaffney, D., Lee-Thorp, J. & Summerhayes, G. Persistent tropical foraging in the highlands of terminal Pleistocene/Holocene New Guinea. *Nat. Ecol. Evol.* **1,** 0044 (2017).
64. Iriarte, J., Denham, T. & Vrydaghs, L. *Rethinking Agriculture: Archaeological and Ethnoarchaeological Perspectives* (Left Coast Press, 2007).

65. Eriksson, J. *et al.* Identification of the yellow skin gene reveals a hybrid origin of the domestic chicken. *PLoS Genet.* **4,** e1000010 (2008).
66. Maxwell, J. J., Howarth, J. D., Vandergoes, M. J., Jacobsen, G. E. & Barber, I. G. The timing and importance of arboriculture and agroforestry in a temperate East Polynesia Society, the Moriori, Rekohu (Chatham Island). *Quat. Sci. Rev.* **149,** 306–325 (2016).
67. Shepard, G. H. & Ramirez, H. "Made in Brazil": human dispersal of the Brazil nut (*Bertholletia excelsa*, Lecythidaceae) in ancient Amazonia. *Econ. Bot.* **65,** 44–65 (2011).
68. Lombardo, U. & Prümers, H. Pre-Columbian occupation patterns in the eastern plains of the Llanos de Moxos, Bolivian Amazonia. *J. Archaeol. Sci.* **37,** 18750–1885 (2010).
69. Rostain, S. *Islands in the Rainforest: Landscape Management in Pre-Columbian Amazonia* (Left Coast Press, 2013).
70. Bush, M. B., Piperno, D. R. & Colinvaux, P. A. A 6,000 year history of Amazonian maize cultivation. *Nature* **340,** 303–305 (1989).
71. Hermenegildo, T., O'Connell, T. C., Guapindaia, V. L. C. & Neves, E. G. New evidence for subsistence strategies of late pre-colonial societies of the mouth of the Amazon based on carbon and nitrogen isotopic data. *Quat. Int.* http://dx.doi.org/10.1016/j.quaint.2017.03.003 (2017).
72. Bayon, G., Dennielou, B., Etoubleau, J., Ponzevera, E. & Toucanne, S. Intensifying weathering and land use in Iron Age Central Africa. *Science* **335,** 1219–1222 (2012).
73. Bellwood, P. Cultural and biological differentiation in Peninsular Malaysia: the last 10,000 years. *Asian Perspec.* **32,** 37–60 (1993).
74. Krigbaum, J. Neolithic subsistence patterns in northern Borneo reconstructed with stable carbon isotopes of enamel. *J. Anthropol. Archaeol.* **22,** 292–304 (2003).
75. Fitzpatrick, S. M. & Keegan, W. F. Human impacts and adaptations in the Caribbean islands: a historical ecology approach. *Earth Env. Sci. T. R. So.* **98,** 29–45 (2007).
76. Prebble, M. & Dowe, J. L. The late Quaternary decline and extinction of palms on oceanic Pacific islands. *Quat. Sci. Rev.* **27,** 2546–2567 (2008).
77. Prebble, M. & Wilmshurst, J. M. Detecting the initial impact of humans and introduced species on island environments in Remote Oceania using palaeoecology. *Biol. Invasions* **11,** 1529–1556 (2009).
78. Fall, P. L. in *Altered Ecologies: Fire, Climate and Human Influence on Terrestrial Landscapes* (eds Haberle, S. G., Stevenson, J. & Prebble, M.) 253–271 (Australian Natl Univ., 2010).
79. Steadman, D. W. *Extinction and Biogeography of Tropical Pacific Birds* (Univ. Chicago Press, 2006).
80. Sheil, D. *et al. The Impacts and Opportunities of Oil Palm in Southeast Asia: What Do We Know and What Do We Need To Know?* Occasional Paper no. 51 (CIFOR, 2009).
81. Fearnside, P. M., Leafl, N. Jr. & Fernandes, F. M. Rainforest burning and the global carbon budget: biomass, combustion efficiency and charcoal formation in the Brazilian Amazon. *J. Geophys. Res. Atmos.* **98,** 16733–16743 (1993).
82. Iriarte, J. *et al.* Fire-free land use in pre-1492 Amazonian savannas. *Proc. Natl Acad. Sci. USA* **109,** 6473–6478 (2012).
83. Preston, D. Exclusive: lost city discovered in the Honduran rain forest. *National Geographic* (2 March 2015); http://news.nationalgeographic.com/2015/03/150302-honduras-lost-city-monkey-god-maya-ancient-archaeology/
84. Edwards, P. *Cambodge: The Cultivation of a Nation, 1860–1945* (Univ. Hawaii Press, 2007).
85. Meggers, B. J. Environmental limitation on the development of culture. *Am. Anthropol.* **56,** 801–824 (1954).
86. Fisher, C. T. *et al.* Identifying ancient settlement patterns through LiDAR in the Mosquaitia region of Honduras. *PLoS ONE* **11**, e0159890 (2016).
87. Webster, D. *The Fall of the Ancient Maya: Solving the Mystery of the Maya Collapse* (Thames and Hudson, 2002).
88. Larsen, M. C. Contemporary human uses of tropical forested watersheds and riparian corridors: ecosystem services and hazard mitigation, with examples from Panama, Puerto Rico, and Venezuela. *Quat. Int.* http://dx.doi.org/10.1016/j.quaint.2016.03.016 (2016).
89. Davis-Salazar, K. L. Late Classic Maya drainage and flood control at Copan, Honduras. *Anc. Mesoam.* **17,** 125–138 (2006).
90. McAnany, P. A. & Gallareta Negrón, T. in *Questioning Collapse: Human Resilience, Ecological Vulnerability, and the Aftermath of Empire* (eds McAnany, P. A. & Yoffee, N.) 142–175 (Cambridge Univ. Press, 2010).
91. Beach, T., Dunning, N., Luzzadder-Beach, S., Cook, D. E. & Lohse, J. Impacts of the ancient Maya on soils and soil erosion in the central Maya Lowlands. *Catena* **65,** 166–178 (2006).
92. Labrière, N., Locatelli, B., Laumonier, Y., Freycon, V. & Bernoux, M. Soil erosion in the humid tropics: a systematic quantitative review. *Agric. Ecosyst. Environ.* **203,** 127–139 (2015).
93. Ford, A. & Nigh, R. *The Maya Forest Garden: Eight Millennia of Sustainable Cultivation of the Tropical Woodlands* (Routledge, 2015).
94. McNeil, C. L. Deforestation, agroforestry, and sustainable land management practices among the Classic period Maya. *Quat. Int.* **249,** 19–30 (2012).
95. Neves, E. G. in *Handbook of South American Archaeology* (eds Silverman, H. & Isbell, W.) 359–379 (Springer, 2008).
96. Fletcher, R. Low-density, agrarian-based urbanism: a comparative view. *Insights* **2,** 2–19 (2009).
97. Simon, D. & Adam-Bradford, A. Archaeology and contemporary dynamics for more sustainable, resilient cities in the peri-urban interface. *Wat. Sci. Technol. Lib.* **72,** 57–83 (2016).
98. Buckley, B. M. *et al.* Climate as a contributing factor in the demise of Angkor, Cambodia. *Proc. Natl Acad. Sci. USA* **107,** 6748–6752 (2010).
99. Lucero, L. J., Fletcher, R. & Coningham, R. From 'collapse' to urban diaspora: the transformation of low-density, dispersed agrarian urbanism. *Antiquity* **89,** 1139–1154 (2015).
100. Barthel S. & Isendahl C. Urban gardens, agricultures and water management: sources of resilience for long-term food security in cities. *Ecol. Econ.* **86,** 224–234 (2012).
101. Isendahl, C. & Smith, M. E. Sustainable agrarian urbanism: the low-density cities of the Mayas and Aztecs. *Cities* **31,** 132–143 (2013).
102. Bush, M. B. & Silman, M. R. Amazonian exploitation revisited: ecological asymmetry and the policy pendulum. *Front. Ecol. Evol.* **5,** 457–465 (2007).
103. Roberts, P. in *Exploring Frameworks for Tropical Forest Conservation: Managing Production and Consumption for Sustainability* (ed. Sanz, N.) 28–44 (UNESCO, 2017).
104. Rostain, S. in *Exploring Frameworks for Tropical Forest Conservation: Managing Production and Consumption for Sustainability* (ed. Sanz, N.) 44–65 (UNESCO, 2017).
105. *Sustainable Development Goals* (United Nations); http://www.un.org/sustainabledevelopment/sustainable-development-goals/
106. Burney, D. A. & Burney, L. P. Paleoecology and "inter-situ" restoration on Kaua'i, Hawai'i. *Front. Ecol. Environ.* **5,** 483–490 (2007).
107. Fraser J. A., Frausin, V. & Jarvis, A. An intergenerational transmission of sustainability? Ancestral habitus and food production in a traditional agro-ecosystem of the Upper Guinea Forest, West Africa. *Glob. Environ. Change* **31,** 226–238 (2015).
108. Sheil, D. *et al.* Do anthropogenic dark earths occur in the interior of Borneo? Some initial observations from East Kalimantan. *Forests* **3,** 207–229 (2012).
109. Glaser, B. & Birk, J. J. State of the scientific knowledge on properties and genesis of anthropogenic dark earths in Central Amazonia (*terra preta de Índio*). *Geochim. Cosmochim. Acta* **82,** 39–51 (2011).
110. Barume, A. *Heading Towards Extinction? Indigenous Rights in Africa: the Case of the Twa of the Kahuzi-Biega National Park, Democratic Republic of Congo* (IWGIA, 2000).
111. Ocheje, P. D. "In the public interest": forced evictions, land rights and human development in Africa. *J. Afr. Law* **51,** 173–214 (2007).
112. Ricardo, B. *Deforestation in Amazonia (1970–2013)* (Instituto Socioambiental, 2012).
113. Rocha, B. C., Jácome, C., Stuchi, F. F., Mongeló, G. Z. & Valle, R. Arqueologia pelas gentes: um manifesto. Constatações e posicionamentos críticos sobre a arqueologia brasileira em tempos de PAC. *Revista de Arqueologia* **26,** 130–140 (2013).
114. Clement, C. R. *et al.* The domestication of Amazonia before European conquest. *Proc. R. Soc. Lond. B Bio. Sci.* **282,** 20150813 (2015).
115. Hobbs, R. J., Higgs, E. & Harris, J. A. Novel ecosystems: implications for conservation and restoration. *Trends Ecol. Evol.* **24,** 599–605 (2009).
116. Bonell, M. & Bruijnzeel, L. A. *Forests, Water and People in the Humid Tropics: Past, Present and Future Hydrological Research for Integrated Land and Water Management* (Cambridge Univ. Press/UNESCO, 2005).
117. World Heritage Forests. *World Heritage Vol. 61, UNESCO* (October 2011); http://unesdoc.unesco.org/images/0021/002139/213912e.pdf
118. Barker, G. *et al.* in *Why cultivate? Anthropological and Archaeological Approaches to Foraging-Farming Transitions in Southeast Asia* (eds Barker, G. & Janowski, M.) 59–72 (McDonald Institute, 2011).
119. Hunt, C. O. & Rabett, R. J. Holocene landscape intervention and plant food production strategies in island and mainland southeast Asia. *J. Archaeol. Sci.* **51,** 22–33 (2014).
120. Marwick, B. *et al.* Early modern human lithic technology from Jerimalai, East Timor. *J. Hum. Evol.* **101,** 45–64 (2016).
121. Kershaw, A. P., van der Kaars, S. & Moss, P. T. Late Quaternary Milankovitch-scale climatic change and variability and its impact on monsoonal Australasia. *Marine Geol.* **201,** 81–95 (2003).
122. van der Kaars, S., Wang, X., Kershaw, P., Guichard, F. & Arifin Setiabudi, D. A late Quaternary palaeoecological record from the Banda Sea, Indonesia: patterns of vegetation, climate and biomass burning in Indonesia and northern Australia. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* **155,** 135–153 (2000).

123. Walker, M. J. C. *et al.* Formal subdivision of the Holocene series/epoch: a discussion paper by a Working Group of INTIMATE (integration of ice-core, marine and terrestrial records) and the subcommission on Quaternary stratigraphy (International Commission on Stratigraphy). *J. Quat. Sci.* **27,** 649–659 (2012).
124. Pearsall, D. in *Encyclopedia of Archaeology* (ed. Pearsall, D) 1822–1842 (Academic Press, 2008).
125. Clement, C. R., De Cristo-Araúgo, M., D'Eeckenbrugge, G. C., Pereira, A. A. & Picanço-Rodrigues, D. Origin and domestication of native Amazonian crops. *Diversity* **2,** 72–106 (2010).
126. Piperno, D. R. The origins of plant cultivation and domestication in the New World trophics: patterns, process, and new developments. *Curr. Anthropol.* **52,** S453–S470 (2011).
127. Kingwell-Banham, E. & Fuller, D. Q. Shifting cultivators in South Asia: expansion, marginalization and specialization over the long term. *Quat. Int.* **249,** 84–95 (2012).
128. Storey, A. A. *et al.* Investigating the global dispersal of chickens in prehistory using ancient mitochondrial DNA signatures. *PLoS ONE* **7,** e39171.
129. Fuller, D. Q. & Hildebrand, E. in *The Oxford Handbook of African Archaeology* (eds Mitchell, P. & Lane, P. J.) 507–526 (Oxford Univ. Press, 2013).
130. Nagarajan, M., Nimisha, K. & Kumar, S. Mitochondrial DNA variability of domestic river buffalo (*Bubalus bubalis*) populations: genetic evidence for domestication of river buffalo in Indian subcontinent. *Genome. Biol. Evol.* **7,** 1252–1259 (2015).
131. Penny, D., Chevance, J.-B., Tang, D. & De Greef, S. The environmental impact of Cambodia's ancient city of Mahendraparvata (Phnom Kulen). *PLoS ONE* **9,** e84252 (2014).

Acknowledgements
We would like to thank the participants of the Pantropica 2016 workshop, funded and hosted by the Department of Archaeology at the Max Planck Institute for the Science of Human History, Jena, for taking part in an international meeting devoted to the global archaeology of rainforest environments. We would also like to thank N. Sanz, and the UNESCO office in Mexico, for invitations to tropical forest conservation workshops in Xalapa (2015) and Mexico City (2017). The discussions that took place during these three workshops informed and shaped the early stages of this manuscript. We would also like to extend our thanks to N. Hofer for her help with Figs 1, 2 and 3. D.E.'s contribution, and N. Hofer's contribution to the illustrations, were funded by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No 639828) in partnership with the APSARA National Authority and the Ministry of Culture and Fine Arts, Cambodia. We also thank the Max Planck Institute for the Science of Human History, Jena for the ongoing funding of P.R. and N.B.

Author contributions
P.R. conceived of the manuscript, wrote the manuscript and conceived of and produced Figs 2 and 3. C.H. wrote the manuscript and conceived of and produced Fig. 1. M.A.-K. wrote the manuscript and conceived of and produced Figs 2 and 3. D.E. wrote the manuscript and conceived of and produced Figs 3 and 4. N.B. conceived of the manuscript, wrote the manuscript and conceived of Figs 2 and 3.

Additional information
Reprints and permissions information is available at www.nature.com/reprints.

Correspondence should be addressed to P.R.

How to cite this article: Roberts, P., Hunt, C., Arroyo-Kalin, M., Evans, D. & Boivin, N. The deep human prehistory of global tropical forests and its relevance for modern conservation. *Nat. Plants* **3,** 17093 (2017).

Publisher's note: Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Competing interests
The authors declare no competing financial interests.