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Por el camino verde: Long-term tropical socioecosystem dynamics and the Anthropocene as seen from Puerto Rico

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Abstract

Islands are traditionally considered sensitive to environment and climate change. The Caribbean Islands are a biodiversity hotspot, where conservation efforts should be a priority. However, the archaeological record suggests that the biotic characteristics of the islands, even within nature or forests reserves, are strongly shaped by thousands of years of intense human activity. This presents an issue for conservation efforts because defining what should be preserved and what should be reconstructed is not straightforward. Using Puerto Rico as case study, this article explores how socioecosystem dynamics influenced the biotic characteristics of the island at specific archaeological periods and to what extent these processes have affected the environmental resources on the island today. Climatic data, its implications on forest type and cover, and landscape characteristics as seen from sedimentary records, combined with archaeological data on human–environment interactions over time, from the mid-Holocene to the present are used to investigate these themes. This article brings forth more questions than answers, but it reflects the status of deep-time environmental research on the island, which is still in its early stages. I argue that, starting from the earliest occupations, human influence has altered the ecology of Puerto Rico so deeply that the natural resources we work toward preserving, conserving, or restoring today cannot be understood without considering the social contexts that shaped them. In this sense, if the Anthropocene is a proposal to rename the current geological period because of the overwhelming physical evidence of change that human activity has left behind, then the history of the Puerto Rico supports the proposal for the application of the term since at least 5 ka. Applying the concept would bring the relevance of human activity to the forefront, contributing to the reconsideration of the role of humans in the formation and preservation of modern ecological systems.

Keywords

Anthropocene, biodiversity hotspot, Caribbean, climate change, landscape change, longue durée, Puerto Rico, socioecosystem dynamics

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The Anthropocene

The Anthropocene concept brings forth the role of humans as an increasingly important force affecting natural processes in our planet and leaving an identifiable anthropogenic marker in the geological record. Archaeologists and specialists in long-term human–environment interaction agree and emphasize that the on- and off-site archaeological record is concrete evidence of the extent and intensity in which people have left their mark in a geologically identifiable way (see papers in this special volume, as well as Balée and Erickson, 2006; Balter, 2013; Butzer, 1996; Certini and Scalenghe, 2011; Crumley, 1993; Graham, 1998; Kirch, 2005; Rick et al., 2013). The issue at stake is not whether the Anthropocene is valid. The relevant question is when does the Anthropocene start? If we are judging the Anthropocene as a time when people caused enough impact as to leave a mark of their presence that could serve as a global indicator of the beginning of a new era (Crutzen, 2002; Crutzen and Steffen, 2003; Crutzen and Stroemer, 2000; Steffen et al., 2007, 2011; Zalasiewicz et al., 2011), is the suggested date of the Industrial Revolution valid? Is it the 'Great Acceleration'? Or is it the earliest physical evidence of human agency affecting other spheres: atmosphere, geosphere, hydrosphere, biosphere (see Certini and Scalenghe, 2011; Erlandson and Braje, 2013; Foley et al., 2013; Rick et al., 2013)?

In this article, the sedimentological and biotic records of Puerto Rico as an oceanic island in the Caribbean are evaluated to measure the intensity of human impact and environmental transformation through time.

Oceanic islands and human settlement: What could we expect

Islands are traditionally considered sensitive to environmental and climate change, especially tropical islands where extinction of species is of serious concern (Fitzpatrick and Keegan, 2007; Rick et al., 2013). The Caribbean Islands are defined as biodiversity hotspots (Helmer et al., 2002; Myers et al., 2000), where richness in species and ecosystem diversity as well as high levels of endemism are considered highly valuable, and conservation

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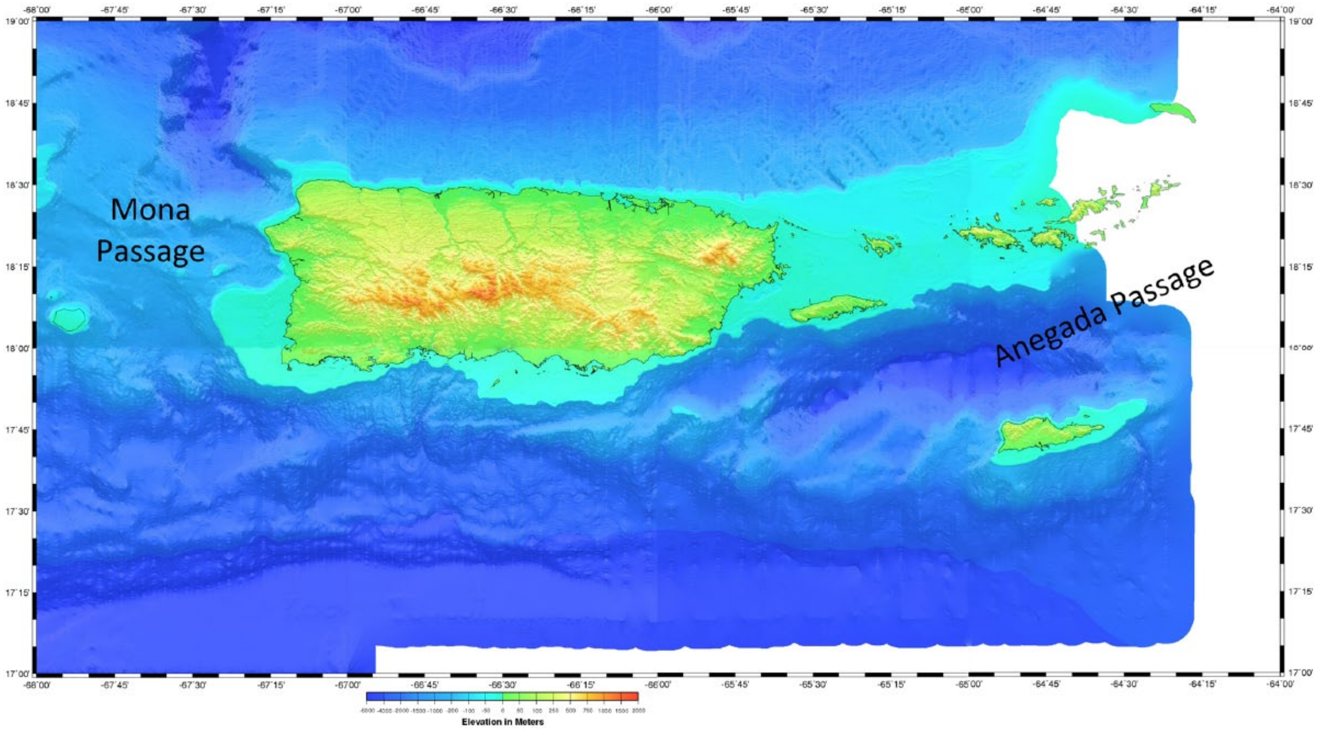

Figure 1. Topographical and bathymetric map of Mona, Puerto Rico, and the Virgin Islands. The lighter colored areas in the bathymetry are shallower than 100 m below modern sea level and could have been exposed as dry land during the Last Glacial Maximum (LGM). This would have merged Puerto Rico and part of the Virgin Islands as one large landmass. However, the deeper bathymetry that separates Puerto Rico, Mona Island, and Hispaniola across the Mona Passage, or Puerto Rico and the Virgin Islands from Saint Croix, Anegada, and the rest of the Lesser Antilles across the Anegada Passage means that even during the lowest of sea level of the Pleistocene, this area was still an island.
Source: GIS data obtained from NOAA National Geophysical Data Center, NGDC Coastal DEM, available at: http://www.ngdc.noaa.gov/dem/squareCellGrid/download/1561 (accessed April 2014).

efforts are sponsored as a priority (Anadón-Irizarry et al., 2012). In Puerto Rico, governmental agencies and NGOs have worked toward creating nature reserves and stimulating nature conservation projects in an attempt to ensure the preservation of biodiversity. One of the largest environmental NGOs on the island, the Conservation Trust of Puerto Rico, recently developed a new brand and aggressive publicity campaign – *Para la Naturaleza* (For Nature, paralanaturaleza.org) – and made its goal to turn 33% of Puerto Rico's territory into nature reserves by 2033. *Para la Naturaleza*'s conservation activities include education, informal learning and citizen science programs, and limiting the kinds of human activities that can be undertaken within the reserves.

When studying islands, the issue between conservation and human agency is contradictory. On the one hand, a discursive line emphasizes island vulnerability: how the delicate balance of biodiversity can be easily disrupted by human presence (Fitzpatrick and Keegan, 2007). On the other hand, modern ecosystems and ecological communities on inhabited islands are taken as the example of rich biodiversity (Anadón-Irizarry et al., 2012), without taking into consideration the long-term role of human activity (see Butzer, 1996 for discussion). For ecological studies, deep-time might mean 50–80 years (see, for example, Gao et al., 2011), even though we know that human activity on most oceanic islands goes much further than that. Conservation efforts, which are often coordinated from ecology, seldom take into consideration the intensity with which human processes have affected and continue to affect the patterns of ecosystem and species abundance and distribution. In the Caribbean, human impact and habitat loss are considered highly significant only after the European colonization ca. 1490 (see Anadón-Irizarry et al., 2012; Baisre, 2010), but little consideration is given to the impact that 4500 years of constant human activity had on the islands before that (see Butzer, 1996), outside of a few studies on the archaeology of the overexploitation of marine resources (Butler, 2010; Curet, 2010; Fitzpatrick, 2010; Keegan, 2010; McClenachan et al., 2010; Pestle, 2013). In this situation, the Anthropocene concept is useful because it emphasizes that humans have had a central role in shaping the characteristics of what we today consider nature.

Por el camino verde: Down the green path of socioecodynamics in Puerto Rico

High endemism in the Caribbean is linked to the formation of the islands as volcanic rocks in the Pacific Ocean during the Cretaceous period and their slow eastward drift during the Eocene, which led to the isolation of populations and eventually to speciation. Many of the islands in the Caribbean Archipelago, and in particular the Greater Antilles, are considered oceanic because of their distance to continental masses, and because many have never been connected to other islands, even during the lowest eustatic sea levels of the Quaternary. During the Last Glacial Maximum (LGM), sea level in the Caribbean reached about 150 m below modern levels (Lambeck and Chappell, 2001; Lambeck et al., 2002). Under these conditions, Puerto Rico would have been connected to adjacent islands such as Vieques, Culebra, and some of the Virgin Islands, but the topography of the sea bottom suggests that there was no land bridge to the Hispaniola through the Mona Passage or to Anguilla, St Martin, and others through the Anegada Passage (Figure 1).

Given the rate of eustatic sea-level rise during the late Pleistocene and early Holocene, much of the early coastal landscapes around the American continents and the Caribbean Islands are currently submerged. Sea level stabilized at 3–5 m below m.s.l. around 7 ka but continued increasing slowly until 2–1 ka (Fleming

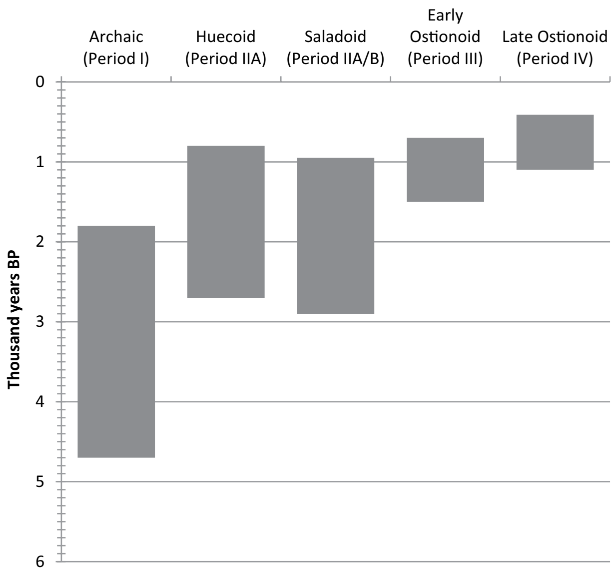

Table 1. Cultural chronologies for Puerto Rico. Dates obtained from Rodríguez Ramos (2010, 2014). The dates for Period I are based on Rivera-Collazo (2011a). The Saladoid period includes the Hacienda Grande (Period IIA) and Cuevas (Period IIB) ceramic styles. In contrast to Rouse's – widely used – chronological model (Rouse, 1992: 52–53), Rodríguez Ramos' analysis of published and unpublished radiocarbon dates demonstrates wide overlap between the different periods.

et al., 1998). As sea level rose, shallow coastal areas flooded, transforming the hydrology, oceanography, and morphology of the coastlines (Peros et al., 2007; Rivera-Collazo, 2011b), and causing inland sediment accumulation due to change in river gradient and decrease in fluvial transport energy.

In Puerto Rico, the earliest evidence for human presence we have so far dates to ca. 4.8 cal. BP (Maruca, Rivera-Collazo, 2011a). An earlier date of 6.8 k uncal. BP date from a charcoal sample for Angostura is not reliable because it has no stratigraphic context and could not be corroborated with other samples from the same unit (Rivera-Collazo, 2011a: 90), while a 5.2 k cal. BP date reported for the Hate Viejo site is considered unreliable because it was obtained from a land snail (Rodríguez Ramos, 2010: 54) (see Table 1 for a general view of the chronological context of Puerto Rican archaeology). Given the shape of the continental shelf around the Greater Puerto Rico landmass, and the evidence for intense fluvial maritime transport activity occurring along the continental Caribbean between 10 and 8 ka (Lathrap, 1973), it is possible that earlier evidence of human activity is submerged, and the sites we today assume as early reflect settlement patterns that correspond to a relatively late configuration of the coastal morphology (Baker-Littman, 2001; Rivera-Collazo, 2011b; Ruppé, 1980).

The Archaic/Pre-Arawak/Period I

The Archaic period in the Caribbean, and in Puerto Rico in particular, represents the first concrete evidence of permanent human settlements on the islands. The mid-Holocene environmental setting of Puerto Rico presented particularly high precipitation, which would have supported broad-leaf forest expansion, high water-table levels, and coastal swamp formation (Higuera-Gundy et al., 1999; Newsom and Wing, 2004; Rivera-Collazo, 2011a; Rivera-Collazo et al., 2015; Silva Dias et al., 2009; Taggart, 1992). Human arrival on the islands ca. 4.8 ka presents evidence of inland exploration, forest clearing for settlement placement, vegetation burning, import of plants and animals from the continent and from other islands, and anthrosol formation (Burney et al., 1994; Rivera-Collazo, 2011b; Rivera-Collazo et al., 2015; Turvey et al., 2007).

It is widely accepted that 'Pre-Arawak' groups originated from the continent, either Central America (Lithic groups), South America (Archaic groups) (Keegan, 1994; Rick et al., 2013), the Isthmo-Colombian area (Pre-Arawak revision, Rodríguez Ramos, 2010), or a combination of these (Wilson, 2007). Notwithstanding their origin, mid-Holocene human settlements in South and Central America contextualized the earliest migrations into the islands. These social contexts are characterized by long-distance exchange networks along rivers and coastlines (Graham, 1987; Hadler et al., 2013; Lathrap, 1973). More intensive research needs to be conducted, but the Archaic period settlement pattern on Puerto Rico suggests a synoptic pattern of large sites near the coast and smaller satellite sites inland, close to rivers and within the forest (Rivera-Collazo, 2011b). Lithic assemblages suggest that maritime connections extended to and encompassed other islands and the mainland for obtaining and exchanging exotic or highly valued rocks such as jadetite, flint, and radiolarian limestone (Rodríguez Ramos, 2010: 81–83, 2011). However, it seems that the main resource that triggered expansion to and incorporation of the Archipelago into the long-distance trade routes of the continent was the exploitation of organic resources that have not yet been identified. Rodríguez Ramos (2015, personal communication) has proposed that, given the elaborate carving traditions seen in lithic assemblages starting in the Archaic period and increasing in complexity toward the late Ostionoid, it is possible that the main resources to be exploited from the islands were dark hard-woods. The few surviving wooden artifacts from the late Ostionoid period from Hispaniola and Cuba (Conrad et al., 2001; Ostapkowicz et al., 2012; Pendergast et al., 2002) support the importance of dark hard-woods for Caribbean societies, and the highly elaborated wood-working skills they developed, both of which are usually invisible in the archaeological record.

Contrary to earlier pre-conceptions regarding Archaic settlement patterns as small transient camps of mobile hunter-gatherers, the archaeological evidence suggests the existence of large settlements that required forest clearing. The geoarchaeological record at the site of Angostura shows a stratigraphy where the cultural layers overlie a soil formed under forested conditions, where clay accreted as the limestone bedrock weathered, and was not eroded because of broad-leaf forest cover (Rivera-Collazo, 2011a: 125–129). The presence of the snail *Alcadia striata* within early layers suggests high humidity, and possibly rainforest composition. This observation is supported by a high precipitation record between 4.0 and 3.3 ka documented in a speleothem collected within the same hydrological basin (Rivera-Collazo et al., 2015), and also suggests a very high water-table that could have kept lower levels within the site partially flooded. As drier conditions returned after this 600-year high precipitation record, the water-table decreased and people started using the previously flooded areas, possibly for cultivation, which eventually lead to the formation of anthrosols (Rivera-Collazo, 2011b) similar to what is known as *terra preta* in Brazil (Graham, 2006; Woods et al., 2009).

Paleobotanical analyses suggest that Archaic peoples brought with them an assemblage of domestic plants and crops that are native to the mainland, including maize, manioc, beans, sweet potato, and cocoyam. Wild native resources were also used, in combination with wild plants imported from the mainland, including marunguey (*Zamia* sp.), achira (*Canna* spp.), wild yam (*Dioscorea*/*Rajania* sp.), seeds of corozo palm (*Acrocomia media*), arrowhead, and arrowroot (Pagán-Jiménez, 2011; Pagán-Jiménez et al., 2005). This economic plant assemblage directly links these sites to the set of phytocultural practices and long-distance trade networks that started developing in the continental Caribbean Neotropics around 7k years ago (Graham, 1987; Lathrap, 1968, 1973; Pagán-Jiménez, 2011). Nonnative animals were also introduced to Puerto Rico during this period. The large rodent *Isolobodon* *portoricensis*, endemic to Hispaniola (Morgan and Woods, 1986; Woods, 1989, 1996), became a diet staple during later cultural periods, being hunted from the wild or kept captive near the sites (Narganes, 2010, personal communication). The earliest evidence of the species in Puerto Rico was recovered at Angostura within a layer dated to 4.1 cal. BP (Rivera-Collazo, 2011a: 113, 132)

Apart from the data recovered from the archaeological sites themselves, human activity during the Archaic period is evident in the geological record as microcharcoal particles combined with increased sediment deposition, and domestic maize phytoliths from lagoon sediment records. Sediment cores from Tortuguero Lagoon (Burney et al., 1994; Caffrey and Horn, 2014; Schoen, 2011) suggests that fire was not a major component of the region's ecology prior 5.3 ka (see Figure 10 in Schoen, 2011: 50). After then, graminoid and woody charcoal incidence increases dramatically, together with significantly higher sediment input to the lagoon basin. The highest microcharcoal values occurred between 4.0 and 3.5 ka, a period that has been documented as very humid (Caffrey and Horn, 2014; Higuera-Gundy et al., 1999; Hodell et al., 1991; Rivera-Collazo et al., 2015). Burney et al. (1994) argue that this charcoal incidence can be linked to human activity given that humidity levels would not have permitted naturally occurring spontaneous fires. In contrast, after comparing sedimentary records from Hispaniola with a new core from Tortuguero, Caffrey and Horn (2014) argue that fire incidence earlier than 3.2 ka is linked to increased winter insolation triggering natural fires. I would argue that, given the characteristics of the local wet-forests surrounding Tortuguero Lagoon and the possibility of Archaic period sites upwind and within the vicinity of the lagoon (Rivera-Collazo et al., 2015), anthropogenic fires might have been the primary source of microcharcoal in the sedimentary record. This subject needs to be evaluated in more detail to quantify the effects of early human impacts on the environment.

A different sediment core from a coastal lagoon close to Tortuguero presented more concrete evidence of human activity by showing maize phytoliths within a layer dated to 2850 cal. BP, earlier than the earliest evidence for Saladoid period settlement at the Maisabel site (Siegel et al., 2005: 111). Microcharcoal in the Tortuguero record decreased around 446–643 cal. AD (1σ) to the present, suggesting a change in demographic and land-use patterns that coincides with the transition from Saladoid to early Ostionoid periods (Burney et al., 1994; Schoen, 2011). Human activity during the Archaic period transformed ecosystems and land forms, creating landscapes that would be adopted and transformed by people during later periods (Balée, 2006).

Ceramic Age (Saladoid to late Ostionoid periods/ Taíno periods, Periods II–IV)

The beginning of the late-Holocene presented new migrations bringing a reshuffling of territories and formation of new settlements during the Saladoid period, as well as more intense exploitation of clays for pottery-making and forest clearance for agriculture (Curet, 2005; Veloz Maggiolo, 1976, 1991). The early Ostionoid also presented the development of complex road systems linking settlements and farmsteads with ball-courts or *bateyes* for individual or communal use (Curet, 1992, 2005; Oliver, 2009; Torres, 2008, 2012). This period is also characterized by an intensification of inland settlement and the development of territories marked with petroglyphs.

Inland expansion brought increased forest clearance and burning for settlement and *batey* sites and agriculture areas (Veloz Maggiolo, 1976, 1991). Maintenance of this infrastructure meant increased investment in forest management. These land-management activities intensified during the late Ostionoid because of demographic increase and *batey* complex expansion (Torres, 2008, 2012). Ceramic Age sites also present a higher investment in agriculture infrastructure, including terracing of slopes, slash-and-burn clearing, and *conuco* or earth-mound cultivation systems (Newsom and Wing, 2004; Veloz Maggiolo, 1991, 2007). Sediment records from the northern coastal plain suggest that these activities provoked soil erosion, as suggested by a significant sediment increase between 1.1 and 0.7 ka (Rivera-Collazo, 2011a: 121–122).

Paleobotanical and historical evidence suggests that people during the Ceramic Age continued utilizing the plants that were initially introduced during the Archaic and others that were introduced later (Pagán-Jiménez, 2007, 2013). The presence of *burenes* (clay griddles) starting in the Saladoid period has traditionally been interpreted as evidence of manioc cultivation, but historical accounts (Coll y Toste, 1907; De Las Casas, 1929) and archaeological research (Pagán-Jiménez, 2013) suggest that the diet and agricultural practices were much more diverse. In addition to cultivation of manioc, agricultural crops included various types of tubers, yams, several varieties of sweet potato, marunguey, lerenes, chili or ají, and beans (Coll y Toste, 1907; Pagán-Jiménez, 2007). Wild plant resources were also intensively utilized, including fruit of native and introduced bushes and trees (Coll y Toste, 1907; Newsom and Wing, 2004), such as Sapotaceae (e.g. mamey (*Pouteria* sp.) and caimito (*Chrysophyllum cainito*)), guava (Myrtaceae), anon (*Annona squamosal*), and jobo (*Spondias mombin*), continuing the Neotropical tradition of arboriculture. Medicinal and ritualistic plants, such as tobacco, *tautúa, tártago*, and *don Tomás* (*Jasopha* spp.) were kept near the houses, within the settlement (Coll y Toste, 1907; De Las Casas, 1929). Not all plants were cultivated or kept in prepared allotments; many were also gathered from 'domesticated landscapes' where the plants had been introduced (Newsom and Wing, 2004; Pagán-Jiménez, 2013).

The protein aspect of the diet was supplied by hunting, fishing, and gathering shellfish, traditions that began during the Archaic period. During the Ceramic Age, people continued importing animals to the islands, including dogs (Wing, 2008), agouti, peccary, and guinea pigs, as suggested by the zooarchaeological record at Carriacou, in the West Indies (Giovas et al., 2012). The effect that all these activities had on the island ecology has not been measured.

Even though more detailed research is needed (Keegan, 2010), it has been argued that pre-Columbian exploitation of marine resources could have had different impacts on the local ecosystems, including the elimination of highly ranked species (Fitzpatrick et al., 2008; Keegan et al., 2003; Pestle, 2013; Wing, 2001; Wing and Wing, 2001). It seems that during the late Ostionoid, the exploitation of offshore resources was intensified in spite of its higher energetic and technological costs, as increased population exerted more pressure on near-shore environments, lowering their productivity (Pestle, 2013; Wing, 2001). This assessment requires additional consideration. For Ceramic Age contexts in Puerto Rico, even though it is possible that overexploitation of resources could have occurred, sustainable management and ocean farming could have also been implemented; however, this still needs to be researched in more detail (Erlandson and Rick, 2010).

Post-European invasion

The end of the 15th century brought a dramatic change to the pan-Caribbean region. The European explorers began releasing Mediterranean and European animals, such as pigs, horses, and cattle, in the islands; these animals were to be hunted in order to re-stock passing ships. Cross-oceanic migration also introduced Mediterranean, African, and European marine fauna, which had not been previously able to cross the Atlantic Ocean, to the Caribbean including African sharks (Rediker, 2008: 37–40) and *Teredo navalis* (Rediker, 2008: 71), the ship-worm that had been a nightmare for Mediterranean boat builders for millennia. The impact of this first invasion on the biodiversity of the islands has not been assessed.

Official colonization during the 16th century brought armed confrontations, forced enslavement, and intra- and inter-island relocation of the local population. As settlements were abandoned, the native population faced severe crises as their trading networks and subsistence traditions were severed during the European invasion. This crisis allowed the forest ecosystems to recover slightly as shown by decreased sediment input on the Grande de Manatí Coastal Plain (Rivera-Collazo, 2011a: 122). Apart from the human crises associated with the Spanish colonization of Puerto Rico, European exploration patterns also brought a new environmental impact. In addition to importing a wide range of viruses that managed to decimate the local populations (Crosby, 1973), Europeans imported foreign domesticates and crops, including bananas, plantains, rice, wheat, coffee, and sugarcane, and released into the wild, knowingly or not, domestic animals such as goats, pigs, and cattle or rats and mongooses (Fahad, 1997; Molina Martínez, 1995; Moreno Fraginals, 1997). The impact that the introduction of these foreign species had on local ecosystems is unknown, although some historians have acknowledged and tried to identify the ecological impact on the Americas (Cronon, 2003; McNeill, 1977).

During the 18th and the 19th centuries, local economies turned to intensive monocrop sugarcane agriculture to supply the European and international markets (Ayala, 1999; Giusti, 2009). This activity, where few plantations bought the sugarcane production of many individual farmsteads, led to the deforestation of almost 90% of the island (Domínguez, 2000; Valdés Pizzini et al., 2011). Sugarcane and coffee were planted everywhere but the most topographically inclined locations. Along the coastal plain, wetlands were drained to create additional land for agriculture (Lugo, 2005: 439–446), and as an attempt to control insect populations associated with disease such as dengue fever and malaria (Giusti, 1994). In addition, irrigation canals and water dams were constructed to ensure sugar productivity, particularly along the southern coastal plain (Plá Cortés, 2005). This activity, in combination with cattle herding and other agricultural and commercial practices, effectively decimated forest cover (see Funes Monzote, 2012 for a similar example in Cuba) and contributed to significant soil erosion and sediment accumulation on coastal plains. Forest cover in Puerto Rico (Figure 2) was still less than 10% by the 1930s, possibly even less than 5% (Aide, 2005; Grau et al., 2003), and was not allowed to recover until after the 1950s, when people abandoned agriculture and turned to the industrial activities sponsored by Operation Bootstrap developed by Governor Luis Muñoz Marín (Grau et al., 2003). Today, over 80% of the island is forested, but these are secondary forests growing on depleted soils. Research conducted by the US Forest Service at El Yunque Rainforest Reserve (Foster et al., 1999) shows human activity has had profound consequences for modern forest ecosystem composition and distribution, even in a protected area such as El Yunque, which was widely deforested until 1936 (Valdés Pizzini et al., 2011). Rapid reforestation following agricultural decline has obscured much of the past land use and confirms the resiliency of some tropical forests to intensive human disturbance (Foster et al., 1999). Recognizing human agency and land-use legacies in modern ecological studies enriches the output of natural resource management programs.

Figure 2. View of the mountainside at the town of Comerío, Puerto Rico, in December 1941. Note the severe deforestation and exposure of the mountainside.
Source: Photo by Jack Delano. Access permitted. Library of Congress, Prints & Photographs Division, FSA/OWI Collection, LC-USF34-048234-D.

Tropical forest socioecology and the Anthropocene

Starting from the earliest occupations, human influence has altered the ecology of Puerto Rico so deeply that the natural resources we work toward preserving, conserving, or restoring today cannot be understood without considering the social contexts that shaped them. The socioecological history of the island suggests that, in contrast with the widely accepted perception of islands as ecologically vulnerable, tropical forests and biodiversity are very resilient and seem to recover quickly. In spite of almost 6000 years of intense human activity modifying the islands, over 70% of all the plants, amphibians, reptiles, and birds, and about 25% of mammals on the Caribbean are endemic (Anadón-Irizarry et al., 2012; Fitzpatrick and Keegan, 2007; Rick et al., 2013). However, little is known of how much has been lost and to what extent the extinction and alteration of endemic ecosystems will affect the future health of modern forests (Butzer, 1996). What does this mean for local ecosystem conservation efforts? This still needs to be looked into.

If the Anthropocene is a proposal to rename the current geological period because of the overwhelming physical evidence of change that human activity has left behind, then the history of the Puerto Rico supports the proposal for the application of the term at least since 5 or 6 kya, as suggested by Rick et al. (2013). Furthermore, applying the concept would bring the relevance of human activity to the forefront, contributing to the reconsideration of the role of humans in the formation and preservation of modern ecological systems. However, the Anthropocene should not be set as a new period, because that would make the term 'Holocene' meaningless. If we would have lived through the Younger Dryas, would we have suggested a new geological period different from the Pleistocene? What about all the other cold/hot bumps of the Pleistocene? While the Anthropocene concept is useful and necessary, applying it only after the Industrial Revolution, less than 200 years ago, means ignoring the relevance of human impact prior to that. I suggest the Anthropocene to be made a synonym of the Holocene, and be used interchangeably for the period after 10 ka.

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