The impact of human activities on the natural environment of the Canary Islands (Spain) during the pre-Hispanic stage (3rd–2nd Century BC to 15th Century AD): an overview

Jacob Morales, Amelia Rodríguez, Verónica Alberto, Carmen Machado, Constantino Criado and Juan Carlos Rando

This paper presents a brief review of archaeological evidence for the impact of the pre-Hispanic population on the environment of the Canary Islands. Prior to human colonisation, the archipelago was an untouched environment with high botanical and faunal biodiversity. The first human settlement can be traced to the early 1st millennium BC; this period of settlement finished at the end of the 15th century AD when the Spanish Crown conquered the archipelago. It has often been assumed that the pre-Hispanic population had little significant impact on the islands' ecosystems. However, abundant evidence for faunal extinctions, deforestation and soil erosion has been recovered from archaeological sites across the islands. This indicates that pre-Hispanic colonisers introduced cultivated plants, opened up the forests to create fields and cut woody vegetation for fuel. They also introduced domestic animals and alien predators resulting in a major depletion of native fauna.

Keywords: Canary Islands, pre-Hispanic stage, human impact, deforestation, faunal extinction soil erosion

Introduction

The Canary Islands are a volcanic archipelago located in the Atlantic Ocean opposite the coast of Africa, at 28° north latitude and only 100 km from the Sahara (Fig. 1). The earliest human occupation started around 3rd to 2nd centuries cal. BC (Galván *et al.* 1999). These immigrants came from northern Africa, but the precise place, or places, of origin is not yet known (Atoche *et al.* 1989; Jiménez 2005; Martín-Guzmán 1986; Martín-Rodríguez 1992). Most specialists agree that the language and material culture of these people had much in common with the Berber (Tamazigh) cultural sphere (Fig. 2). There is no evidence that after colonisation there were contacts with the mainland or even among the different islands. Every island developed a distinctive culture, until Europeans first landed around the middle of the 14th century AD. At the end of the 15th century AD, after 150 years of commercial contacts, Christianisation, political treaties and military campaigns, all the islands were conquered by the Spanish Crown.

Most of the European travellers described the archipelago as a paradise, the fortunate islands, overflowing with natural abundance, a place where there was almost no need to work to get a good harvest. The landscape was God-given in its abundance, and the ancient Canarians were its carefree recipients.

Until recently, the dominant perception of archaeologists with regards the pre-Hispanic cultures and their environment has been to see the landscape largely as an unchanging backdrop against which history was played out. The implicit assumption that the indigenous population had little significant impact on the islands ecosystems has also underlain much paleoenvironmental research in the region (Morales 2003). But we now know that all human groups have an impact on their environment, whether hunter-gatherers or farmers. The aim of this paper is

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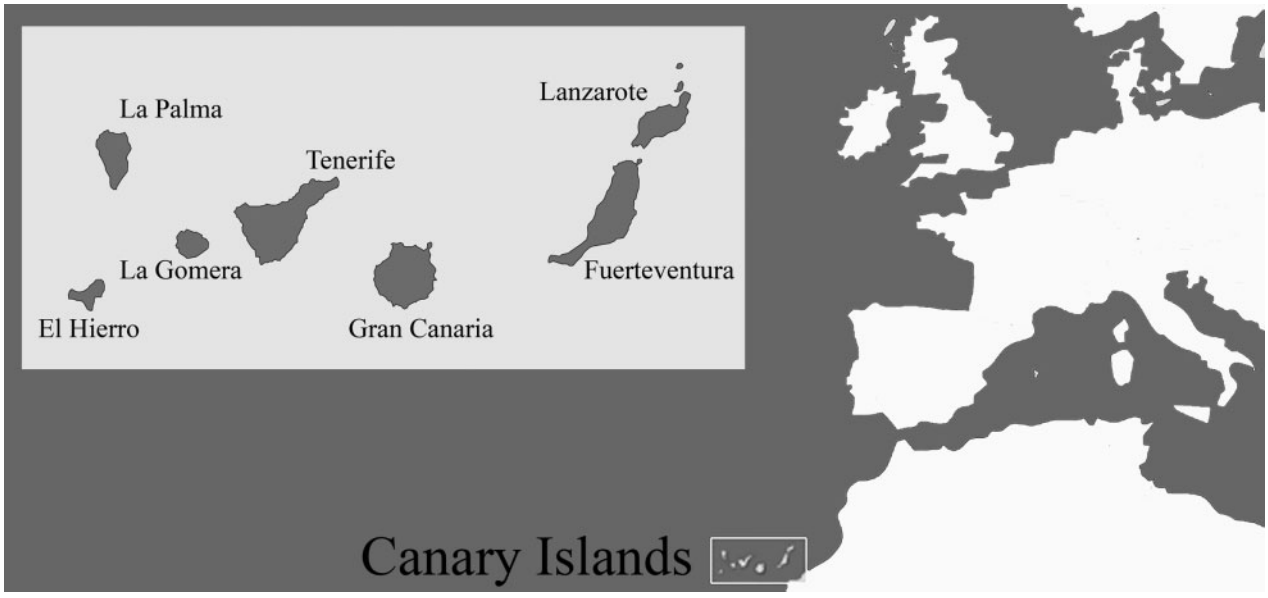

Figure 1 Map of the Canary Islands

to review the evidence for pre-Hispanic impact on the environment. We see the landscape as the material product of the relationship between people and their environment. This landscape is constantly changing, as a consequence of both environmental fluctuations and the peculiarities of each human society. These changes in turn affect later human populations.

In this paper the focus will be on selected archaeological features that allow insight into aspects of pre-Hispanic society in the Canary islands. However, well-excavated stratigraphies are restricted to some islands, and only in the last two decades have radiocarbon dates been systematically used in archaeological research. In addition, there are some problems of absolute dating due to the modern intrusion of rodents and lizards in archaeological layers, and also as a consequence of the historical volcanic eruptions in the archipelago (Soler *et al.* 2002). This makes it difficult to establish coherent sequences of paleoenvironmental data for each island. In spite of these difficulties, the data presented in this paper is important because it shows archaeological evidence of a significant human impact on the islands ecosystems that can be linked with the first colonisers of the Canaries.

Figure 2 Lybian-Berber inscriptions from pre-Hispanic period, Gran Canaria

Natural conditions of the Canary islands

The archipelago consists of seven islands and several islets of volcanic origin, which could be classified into two groups depending on their topography and climatology. Firstly, Fuerteventura and Lanzarote lack high mountains and are very dry because of their proximity to the continent. Secondly, the Western islands, Gran Canaria, Tenerife, La Gomera, La Palma and El Hierro, are uneven in altitude, from 1501 m in El Hierro to 3718 m in Tenerife, which generates many different ecosystems.

The Azores anticyclone that causes the trade winds during most of the year dominates the climate. These winds keep the temperature constant during most of the seasons. Atlantic depressions and the Sirocco or Calima (Sahara dust invasions) are the other main climatological features affecting the islands' weather.

As a consequence of these climatic agents and the geographical isolation, the islands present a tremendous botanical and animal biodiversity. Whereas in Lanzarote and Fuerteventura the vegetation is more homogenous, in the rest of the archipelago the altitude and orientation towards the trade winds

Table 1 List of animals introduced in the Canary Islands during the pre-Hispanic period according to archaeological evidence

species	Fuerteventura	Lanzarote	La Palma	La Gomera	El Hierro	Tenerife	Gran Canaria
Capra hircus, goat	x	x	x	x	x	x	x
Ovis aries, sheep	x	x	x	x	x	x	x
Sus domesticus, pig	x	x	x	x	x	x	x
Felis catus, cat			x			x	
Canis familiaris, dog	x	x	x	x		x	x
Mus musculus, house mouse	x				x		

creates several bioclimatic layers with many species. Currently, there are 2000 wild plants, of which 1000 are autochthonous, with 523 of them being endemic to the islands (Marrero and Pérez 1997).

With regards indigenous fauna, the Canaries display a common characteristic with other oceanic islands, that is, the absence of big non-flying terrestrial mammals. Only groups of vertebrates with a better dispersion capacity such as reptiles, small mammals and, especially, birds were able to reach the Canary Islands in the past (Rando 2002). After this first wave of colonisation, different species evolved in unique ways due to the isolation of the islands, leading to the appearance of species exclusive to the archipelago. Typical examples are the reptiles, which are 100% endemics to the islands (Báez 1984).

The pre-Hispanic societies

Pre-Hispanic subsistence strategies were based on food production as well as fishing, hunting, gathering wild plants and marine shellfish. The first inhabitants introduced five domestic species, namely goats (*Capra hircus*), sheep (*Ovis aries*), pigs (*Sus domesticus*), cats (*Felis catus*) and dogs (*Canis familiaris*) (Arco *et al.* 1992; Pais 1996). The economy of the first settlers was focused on agriculture and domestic animal husbandry. In most of the islands food production depended heavily on animal husbandry, especially on goats and sheep. The bones of these animals have been recovered in large numbers in almost every domestic site on the islands (Table 1). Dietary studies on human bones have also shown the importance of animal husbandry, emphasising the dependence on secondary products from livestock, mainly milk (Delgado 2001; González and Arnay 1992; González *et al.* 2001; Pérez 2000; Velasco 1999; Velasco *et al.* 1997). All the islands apart from Gran Canaria show this pattern of food production. In contrast, on Gran Canaria, most of the available food derived from arable agriculture (Velasco 1999). There is archaeological evidence for arable husbandry practices in all the islands, except Fuerteventura and Lanzarote. This indicates that the most important crop was barley (*Hordeum vulgare*). Wheat (*Triticum durum*), lentils (*Lens culinaris*), field beans (*Vicia faba*), peas (*Pisum sativum*) and figs (*Ficus carica*) were also introduced to the islands by pre-Hispanic people, though some islands lacked one or more of these species (Table 2) (Morales 2003; 2006).

The material culture was very rich, with a large selection of hand-made pottery, flaked and polished lithic industry, and tools and other artefacts made from bone, leather, shell, vegetal fabrics and wood (Tejera and González 1987).

Like the economic activities and natural resources, social complexity varies from one island to another. Taking into account the archaeological and the ethnohistorical sources, it has been possible to draw a division between Gran Canaria and Tenerife on the one hand, and the rest of the islands on the other (Velasco *et al.* 1999). The data from the first group show that there was a considerable social hierarchy. In both islands two social classes were described by the earliest European travellers. Firstly, there was a high class of chieftains, who did not intermarry with another class but only with each other, sometimes even with siblings or half-siblings. They controlled the property of the means of production, the land, the

Table 2 List of cultivated plants introduced in the Canary Islands during the pre-Hispanic period according to archaeological evidence

species	Fuerteventura	Lanzarote	La Palma	La Gomera	El Hierro	Tenerife	Gran Canaria
Hordeum vulgare, barley			x	x	x	x	x
Triticum durum, hard wheat			x			x	x
Pisum sativum, pea							x
Vicia faba, faba bean			x			x	x
Lens culinaris, lentil			x				x
Ficus carica, fig						x	x

harvest and the livestock. Secondly, there was a lower class that was occupied in agriculture, livestock keeping and production of crafts (Velasco *et al.* 1999). In the rest of the archipelago the evidence indicates that there was not such a pronounced hierarchy. The social structure of these population groups was based on kinship while social classes are not mentioned (Tejera and González 1987). Finally and surprisingly, the lack of any kind of information on possible contacts with people from other islands in the archipelago should be noted, despite their proximity.

The impact of pre-Hispanic societies on the environment of the archipelago

There were various kinds of changes in the indigenous flora and fauna of the Canaries during the pre-Hispanic occupation: some introductions, some restrictions of range, various localised changes in composition and diversity, and changes in frequency distribution. However, here only faunal extinctions, deforestation and soil erosion will be considered (Table 3).

As a way of marking the link between social complexity and environmental impact it is necessary to make an artificial division between, on one hand, Tenerife and Gran Canaria, and on the other hand, the small islands.

The small islands (Fuerteventura, Lanzarote, La Palma, La Gomera and El Hierro)

In this group of islands a distinction must be made between Fuerteventura and Lanzarote on the one hand, and La Palma, La Gomera and El Hierro on the other. The former islands are flat and drier, and therefore their vegetation cover is more prone to destruction due to human impact. The latter are wetter and mountainous, and nowadays still have important forests.

Deforestation is a consequence of both the use of wood as fuel, and the opening up of land for agriculture and pastoralism. This can be observed in Fuerteventura and Lanzarote where no natural forests are now found. However, in the case of Fuerteventura analyses of charcoal from the Villaverde's cave site offer some interesting information. Levels dated from the 3rd to the 7th century AD contain species that are not presently found on the island, such as laurels (*Laurus azorica* and *Persea indica*) and strawberry tree (*Arbutus canariensis*). All these species require high humidity and are nowadays confined to the laurel forests of the most mountainous islands. In later levels, from the 9th century AD

Table 3 The main archaeological evidence of human impact on the environment of the Canary Islands (F = Fuerteventura; L = Lanzarote; P = La Palma; G = La Gomera; H = El Hierro; T = Tenerife; C = Gran Canaria)

Island	Ecology	Social Complexity	Deforestation	Soil erosion	Animal extinctions							
					M. monachus	*M. insularis*	*C. bravoi*	*C. tamarani*	*G. goliath*	*P. olsoni*	*C. gomerae*	*A. gentilis*	*Pterodrama* sp.
F	dry/flat	egalitarian	×		×	×				×	×		
L	dry/flat	egalitarian		×		×				×			
P	wet/mountainous	egalitarian	×						×		×		
G	wet/mountainous	egalitarian									×		
H	wet/mountainous	egalitarian									×	×	×
T	wet/mountainous	hierarchical	×				×		×				
C	wet/mountainous	hierarchical	×	×				×					

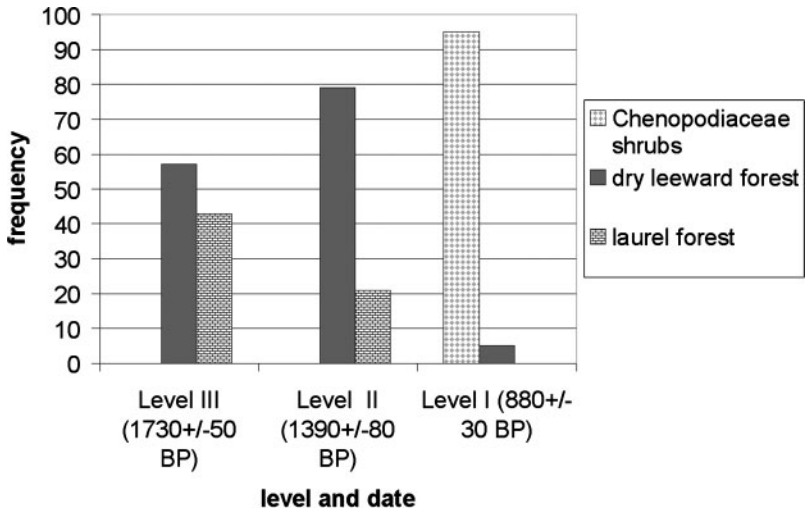

Figure 3 Frequency and origin of charcoal in archaeological levels from Villaverde's cave site, Fuerteventura

onwards, this range of trees disappears completely (Fig. 3) (Machado 1996).

In Fuerteventura alterations to the vegetation and the complete elimination of the indigenous forests, together with the introduction of new animals and hunting caused the extinction of some animals. *Malpaisomys insularis*, a small mouse that lived in the lava field, and an endemism of Lanzarote and Fuerteventura, became extinct in the 14th century AD. It was replaced by the common house mouse (*Mus musculus*) which was introduced by the pre-Hispanic population (Michaux *et al.* 2007). Similarly, seals (*Monachus monachus*) were almost extinct, with only a few individuals left by the time the first Europeans arrived on the island. In this case, seal bones have been recovered from archaeological sites indicating that hunting by pre-Hispanic people may have reduced the size of this population (Meco 1992). Nowadays, no seals are left in the Canaries.

Apart from those mammals, two distinct endemic species of bird became extinct in Fuerteventura: a seabird (*Puffinus olsoni*) that nested in lava fields and a flightless species of quail (*Coturnix gomerae*). Bones from both birds have been recovered from archaeological sites, indicating that hunting may have been one of the main causes of their extinction (Rando and Perera 1994). Nesting in accessible lava fields and the inability to fly favoured the consumption of these species by humans as well as by the mammals introduced by humans, such as dogs.

In Lanzarote, in addition to the extinction of *Malpaisomys insularis* and *Puffinus olsoni* (Martín-Oval *et al.* 1998; Mcminn *et al.* 1990), significant anthropogenically induced soil erosion has been documented (Atoche 2003; Criado and Atoche 2003; 2004; Criado 2005). Sedimentological analysis of stratigraphic column samples taken from three different locations on Lanzarote provides insight into rates of soil erosion on the island. An increase of grain-size in layers dating from the 1st century BC to the 14th century AD along with increasing levels of carbonates and phosphoric oxide, indicate significant soil degradation (Fig. 4). Bones of sheep and goat are abundantly present in the analysed layers, which could suggest that overgrazing was an important factor in this process. The island of Lanzarote has a semi-arid environment, and thus the impact of the introduction of these two animals was very significant. Nevertheless, it is very difficult to be certain that overgrazing was the sole cause of this soil erosion, or whether there was a convergence between overgrazing and climatic deterioration (Atoche 2003; Criado and Atoche 2003; 2004; Criado 2005). Unfortunately, there are no palaeoclimatic data from the Canary Islands concerning the recent Holocene to support this hypothesis. We only have data from the Atlantic coast of Morocco, with similar levels of rain, which indicates that there are not significant changes in the climate during the last two millennia (Vernet 1995).

In La Palma Island, charcoal analysis from the cave of El Tendal shows a change in the pattern of wood gathering for fuel during the pre-Hispanic occupation. In older strata, dating from about the 1st century BC, trees which do not require high humidity, such as holly (*Ilex canariensis*) and fayas (*Myrica faya*) were plentiful. However, in younger strata dating to the 7th century AD, species such as the laurels (*Laurus azorica*), which require high level of humidity that can be only found high up in the

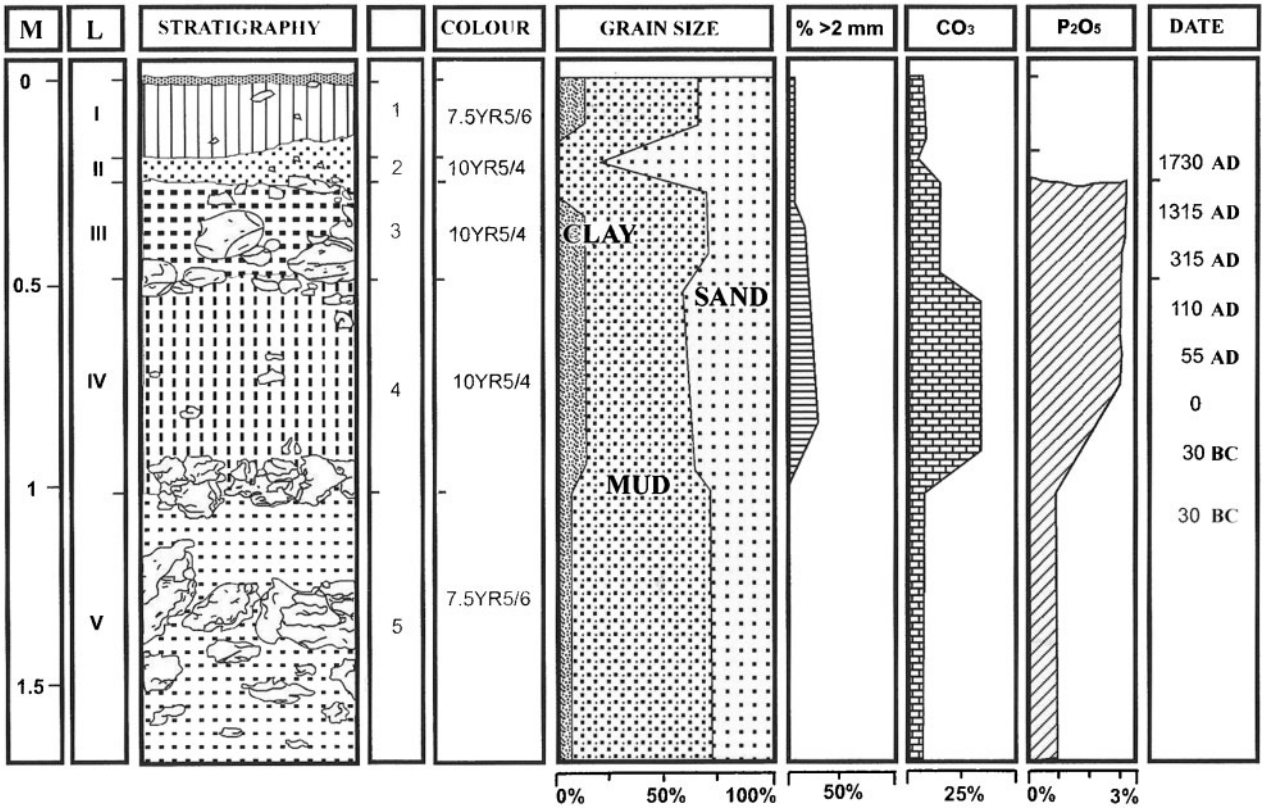

Figure 4 Representation of the stratigraphical cross-section from El Bebedero site, Lanzarote

mountains, had increased considerably (Fig. 5). This is thought to reflect the exploitation of new species situated at a considerable distance from the cave due to the overexploitation of species available in the immediate surroundings (Machado 1995).

As in Fuerteventura and Lanzarote, in La Palma some extinctions have been recorded in which the first inhabitants of the archipelago must have played a part. These extinctions concern the endemic quail (*Coturnix gomerae*) and a large lizard endemic to the canaries, the *Gallotia goliath* (Alberto 1998; Navarro *et al.* 1995). This lizard was up to one and a half metres in length and lived all over the island (Fig. 6). The isolated evolution of these animals favoured a giant habitus that made them simultaneously vulnerable and attractive to humans.

A further potential animal extinction has been identified in La Gomera Island. The animal

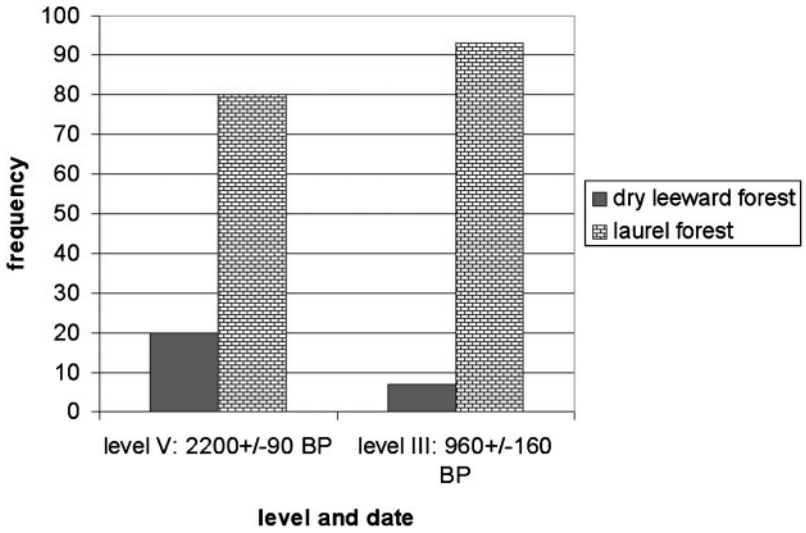

Figure 5 Frequency and origin of charcoal in archaeological levels from El Tendal site, La Palma

Figure 6 Archaeological bones (humerus) of giant lizards (a) *Gallotia galloti* and (b) *Gallotia goliath* from Tenerife island

concerned was the flightless quail (*Coturnix gomerae*), whose remains have been recovered from a paleontological site on the island (Jaume *et al.* 1993). Nowadays this quail does not live in La Gomera, but as yet no archaeological data exist to ascribe its extinction to the pre-Hispanic population.

In El Hierro Island the flightless quail (*Coturnix gomerae*) and a giant lizard (*Gallotia simonyi*) whose population has now been reduced to a single location, isolated from the rest of the island, have been recovered from archaeological sites (Martín-Oval *et al.* 1987; Rando *et al.* 1997). Furthermore, one species of petrel (*Pterodroma* sp.) and a goshawk (*Accipiter gentilis*) are extinct in El Hierro. Bones from these two birds have been recovered from a paleontological site, in a volcanic cave (Rando 2002). Although in both cases extinction seems to have been associated with the human occupation of the island, the pre-Hispanic impact on these species cannot be evaluated due to the scarcity of archaeological data.

The large islands (Tenerife and Gran Canaria)

On Tenerife, a goal at several archaeological sites has been to determine the nature of the surrounding woodland and its evolution through the pre-Hispanic period. Several chronological sequences show a change in the environment, associated with anthropogenic activities, mainly agriculture and cattle raising. This impact is clearly seen in a decline in wood fuel collected from the leeward dry forest between the first occupation and the 12th-15th centuries AD (Fig. 7). In the latter period, wood for fuel was collected instead from the laurel forest because of a lack of the former trees (Machado *et al.* 1997). In Las Cañadas del Teide (over 2000 m high) between the 13th and 15th centuries AD many trees species disappeared, such as pine (*Pinus canariensis*) and cedar (*Juniperus cedrus*), in favour of fodder plants and shrubs (Machado and Galván 1998).

In addition to changes in the woody vegetation, faunal extinctions have been documented on the island of Tenerife. Both a giant rodent (*Canariomys bravoi*), endemic to this island, and a giant lizard (*Gallotia goliath*) became extinct. *Canariomys bravoi* had approximately the size and the weight of a rabbit. This giant rat was omnivorous and used to live in wet and forested places, where it climbed into trees to

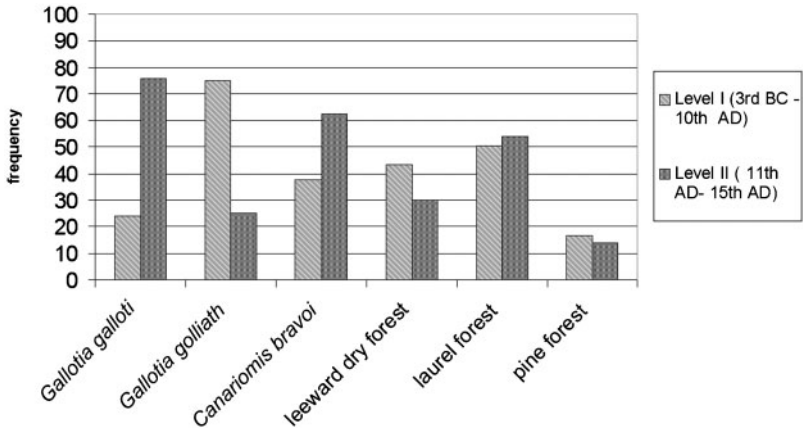

Figure 7 Frequency of native fauna and vegetal cover in the archaeological site of Arenas-3, Tenerife

Table 4 Fauna remains from Las Arenas I site, Tenerife

	Arenas I, Tenerife				
Species	**Level III**	**Level II**	**Level I**	**total**	**%**
Ovicaprid	55	23	36	114	10,8
Capra hircus		1	1	2	0,2
Sus domesticus	2	2	1	5	0,5
Canis familiaris	7		7	14	1,3
Canariomys bravoi	241	13	157	411	38,9
Gallotia goliath	175	10	131	316	29,9
Indeterminated birds	19	2	5	26	2,5
Inteterminated	134	16	18	168	15,9
total number of bone fragments	633	67	356	1056	100
Uncalibrated date	1480 BP	no data	surface		

feed. Bones of this species have been collected in both paleontological and archaeological sites (Alberto 1998) indicating that the pre-Hispanic population consumed these rodents (Fig. 7 and Table 4). Although the date of their extinction is not precisely known, evidence from the cave of La Fuente points towards a late date, around the 12th and 13th century AD (Galván 1991).

Similarly, the giant lizard (*Gallotia goliath*) has been recorded in many paleontological and archaeological sites on Tenerife (Fig. 6 and Table 4). The presence of its bones in archaeological sites falls progressively through time, suggesting an important pre-Hispanic influence in the extinction of this reptile (Fig. 7). However, there are early historical references to the presence of this lizard in the 15th century, which indicates that it became extinct at some point during the first years of the European occupation of the island (Alberto 1998).

In Gran Canaria Island one of the most important sites is Hogarzales, a complex of mines where obsidian was exploited. Nowadays there is no forest cover in this area, but in archaeological strata dating to the 11th century AD charcoal from several tree species, including strawberry tree (*Arbutus canariensis*) and holly (*Ilex canariensis*) was identified (Martín-Rodríguez *et al.* 2001). Moreover, around the mines, waste products of the quarrying process were found in abundance, creating a stratum of human origin that covers the entire surface.

A similar pattern can be seen at El Burrero, on the east coast of Gran Canaria. The present flora of this area is very arid, but two structures dating to the 6th and 11th centuries AD, respectively, show a different picture of the past flora. Most of the charcoal on this site belongs to species that require high humidity and nowadays are found only in the mountains or are even extinct in Gran Canaria, such as *Rhamnus glandulosa* (Table 5) (Mireles *et al.* 2005). This suggests a remarkable change in the forest cover in the mountain area nearest to the site.

Another consequence of forest clearance is the accelerated erosion. At Cendro, a large settlement of carved caves and houses, a significant phase of soil erosion phase has been documented. This episode has been linked to the pre-Hispanic population due to the prevalence of ceramics in this sediment. Overgrazing of goat and sheep, as well as agricultural activities are considered the primary causal factors for environmental degradation in this case (Criado and Hansen 2002).

Table 5 Charcoal remains from El Burrero site, Gran Canaria

	El Burrero, Gran Canaria			
Species	**Level II**	**Level I**	**total**	**%**
Angiosperm	2	24	26	9,2
Gimnosperm	2		2	0,7
cf *Picconia excelsa*		4	4	1,4
Pinus canariensis	46	83	129	45,7
Rhamnus glandulosa		1	1	0,35
Rosaceae		2	2	0,7
Salix canariensis	46	56	102	36
Salicaceae	2	3	5	1,8
Viburnum tinus		11	11	3,9
total number of charcoal fragments	98	184	282	100
Calibrated date	340–650 AD	980/1050–1100/1140 AD		

In Gran Canaria, besides the consumption of the giant lizard (*Gallotia stehlini*) (Martín-Rodríguez *et al.* 1999), the extinction of a giant rat (*Canariomys tamarani*) has been recorded. *Canariomys tamarani* was endemic to this island; it measured 30 cm and weighed around 1 kg. Some rat bones have been recovered from a cave with paleontological and archaeological remains (López-Jurado and López-Martínez 1991). However, there is not enough available evidence to precisely date the extinction of this giant rodent.

The pre-Hispanic landscape. A chronicle of the socialisation of the Canary islands

The pre-Hispanic colonisation of the Canaries was a unique event in a new scenario for the old world cultures. The archipelago was an untouched environment never previously occupied by humans. While some early European travellers described the islands as a paradise, it is questionable whether human populations could have made an easy living on the islands without an agricultural and farming economy based on introduced plants and animals. Few edible plants were naturally available, and the only edible non-marine fauna of any significance were giant rodents (only in Tenerife and Gran Canaria), birds and lizards. The first people to inhabit the islands brought with them a series of domesticated animals and plants. They introduced agriculture, established fields and opened up the forests to create pasture and cut woody vegetation for fuel. As a result a managed and more productive environment was created, capable of supporting dense human population. Whilst beneficial, these changes also brought damage to the native flora of the archipelago. Moreover, the overgrazing of sheep and goat in the arid zones of the islands accelerated soil erosion.

Another effect of this massive vegetation alteration was the removal of the habitat of many species of birds, lizards and rodents, causing changes in their populations, which in some cases provoked their extinction. Later, hunting by pre-Hispanic people and, especially, the massive presence of alien predators and rats after the European conquest, resulted in a high lost of native animals.

Pre-Hispanic societies constructed their own ecological niches, characterised by certain animal and plant species, and land exploitation. Domestic animals, crops, mouse and weeds characterise this human niche and their remains were detected in almost every archaeological site of the islands. The weeds consist of plants that grow in the islands only under conditions of human disturbance, and they have been linked in some archaeological sites of the islands with social landscapes such as fields, pastures or human settlement (Morales *et al*. 2004; Morales 2006).

A loss of biodiversity is now well documented as one of the major environmental consequences of human colonisation of oceanic islands (Kirch and Hunt 1997). The situation in the Canary Islands is similar, though it is worth pointing out that here the extinctions occur relatively late in the islands occupation. Many extinctions date to the period just before or just after the Hispanic occupation. There might be several reasons for this, but possibly the most likely is that the first occupants of the islands were agriculturalists concerned with their domestic crops and animals, not with the wild plants and animals. Thus, the extinctions may be the result of the deterioration of the ecological habitats through farming, rather than exclusively due to direct hunting.

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