

Hunter-gatherer plant resource use during the Holocene in central western Patagonia (Aisén, Chile, South America)

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Abstract Recent archaeobotanical studies on hunter-gatherer sites in the steppes of central western Patagonia, Chile, reveal new data on the use of plant resources throughout the Holocene, often previously assumed to be unimportant. The plant macroremains from two cave sites, El Chueco 1 (~11,500–180 cal BP) and Baño Nuevo 1 (~10,800–3,000 cal BP), indicate that hunter-gatherers used locally available plants, of both restricted and extensive distributions, during the entire occupational sequences there. Due to the nature of these remains, we may indirectly infer their potential use as food, food sub-products, for fuel, or for making artefacts. Plant taxa, used as a seasonal indicator, suggest spring-summer occupations in the different periods of time defined for each site. Archaeobotanical data have proven valuable in complementing our view of the subsistence economy of prehistoric Patagonian steppe hunter-gatherer groups, not only by defining the botanical assemblages associated with the occupations, but also by contributing to define seasonality and the mobility strategies related to plant use.

Keywords Plant resources · Plant macroremains · Hunter-gatherers · Holocene · Patagonia

Introduction

All human groups develop strategies to use their surroundings. To understand the hunter-gatherers' ways of life it is essential to learn how human groups interacted with their environment and organized themselves to use these resources (Kelly 1995). In the archaeology of hunter-gatherer sites, the more frequent preservation and the greater visibility of bone remains have contributed to the dominant view that hunting resources were more important than gathering plants (Hather and Mason 2002; Walker and Driskell 2007). Patagonia, in southernmost South America, is a fertile ground for assessing this problem because: (a) only hunter-gatherers occupied the region since the Pleistocene-Holocene transition (Borrero 2008) and (b) animal protein resources have been assumed to be the basis of diets, spatial organization and the seasonal use of resources there. Although this conception is largely based on solid evidence gathered from a significant number of archaeological sites (Mengoni 1999; Miotti 2012) and from numerous ethnographic accounts of the reliance on hunting (Gusinde 1982), the lack of data explaining how plants were used by these groups is due to the fact that the recovery of plant remains has not been a standard procedure on many excavations. There is a great need to systematically recover plant remains in order to integrate them into discussions of the past behaviour of steppe hunter-gatherers. Therefore, plant remains should be examined from various perspectives, including their selection as resources, the technology used in obtaining them, their processing and disposal.

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There is no doubt that archaeobotanical evidence can function as a strong archaeological indicator of space use, subsistence and mobility, among other things. It can indicate which plant taxa were used, thus making it possible to understand the exploitation strategies and uses of these resources (Ford 1979; Bonzani 1997; Rodríguez 1997, 2001, 2004). From this perspective, it is possible to determine what environments were being used, based on the taxa identified at the sites, by locating their source areas. Mobility strategies related to plant procurement may also be detected, thereby providing information on the cultural behaviours associated with plant use. Finally, it is possible to evaluate the occupation of different environments and to determine seasonality (Monks 1981).

In Patagonia, archaeobotany has played a minor role in defining subsistence practices due to the fragility of this type of evidence and its low density and visibility in the archaeological record. The few attempts to integrate this line of analysis have been able to reconstruct plant use practices and contribute to the understanding of how these

resources were involved in subsistence strategies. Most of these studies have been undertaken in Argentina and were mainly based on the study of evidence from charcoal (Solari 1989–1990, 1993–1994, 2009; Pique i Huerta 1999; Caruso 2012), as well as ethnobotanical and ethnoarchaeological studies (Ragonese and Martínez-Crovetto 1947; Martínez-Crovetto 1968, 1982; Pérez de Micou 1991; Rapoport and Ladio 1999; Ladio 2001, 2004; Rapoport et al. 2003; Frank 2011–2012, 2012; Ciampagna and Capparelli 2012). Plant macroremain studies have only recently been done (Belmar 2011; Méndez et al. 2011; Ciampagna 2014; Capparelli and Prates 2015), as well as microfossil studies (Musaubach 2014; Musaubach and Berón 2017).

By analysing the seed record of hunter-gatherer sites we can study the past use of plant resources in the Aisén region of central western Patagonia, Chile (CWP; Fig. 1) as a case study for assessing subsistence practices, mobility and seasonality. Thus, we put forward the data from two archaeological sites that had recurrent occupations throughout the Holocene, El Chueco 1 (EC1, ~11,500–180 cal

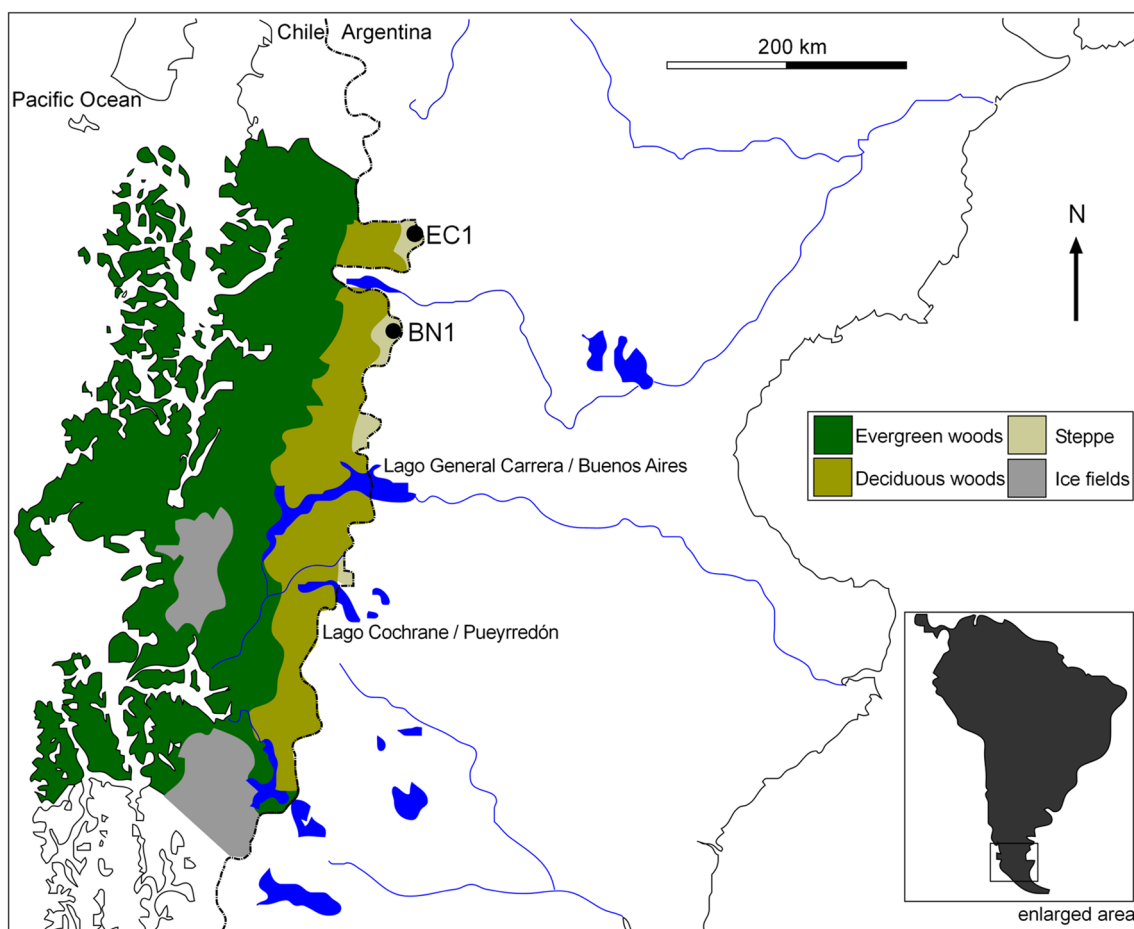


Fig. 1 Map of central western Patagonia (CWP, Aisén region) with the main vegetation communities and the studied archaeological sites El Chueco 1 (EC1) and Baño Nuevo 1 (BN1)

BP; Méndez et al. 2011, 2016b) and Baño Nuevo 1 (BN1, ~10,800–3,000 cal BP; Mena and Stafford 2006). Both cave sites have long occupational sequences; as such they allow long-term comparative studies, which are absent from the current regional literature. Even though they share some similarities, they have different occupational modes. EC1 is characterized by a stratified succession of short separate occupational events (Reyes et al. 2009; Méndez et al. 2011), whereas BN1 was more intensively used during some periods and particularly as a funerary context during a brief period in the early Holocene (Mena et al. 2003; Reyes et al. 2012). The integration of this new type of data will allow a comparison of both plant assemblages, which can provide insights on similarities and differences in plant use strategies, as well as on the seasonality of the different occupational events. Furthermore, it will also allow assessment of the mobility strategies related to plant gathering.

Study area

Regional setting

The Aisén region of central western Patagonia covers ~110,000 km². It has a dry continental climate with an average annual precipitation of 400 mm and an average annual temperature of 7 °C (Luebert and Plissock 2006). It is characterized by a steep biogeographical gradient from the wooded archipelagos of the Pacific coast to the steppe plains east of the Andes, thereby generating varied ecosystems over short distances. Three main regions have been described from west to east: (a) the evergreen woodland region; (b) the Andean-Patagonian woodland region and (c) the scrub and Patagonian steppe region (Gajardo 1993). These regions are cut through by a series of valleys connecting these environments. The studied sites are located on the steppe to the east of the Andean mountain range, on extensive plains bordered by low ridges (SERPLAC 2005), formed by glacial activity during the late Pleistocene (Méndez et al. 2016a). Vegetation in this area is known as Mediterranean-temperate *Festuca pallescens* and *Mulinum spinosum* steppe (Luebert and Plissock 2006). It consists of xerophytic taxa, including sedges, grasses and herbaceous plants. However, some patches of woodland can be observed near watercourses. The faunas of steppe environments are characterized by low variability, with one mid-sized dominant ungulate, *Lama guanicoe* (guanaco), which in the past was more abundant and a reliably available resource.

Paleoenvironmental history

Local palynological studies on Lago El Shaman and Lago Mallín El Embudo (De Porrás et al. 2012, 2014), in the

valley of the river Cisnes (Fig. 1), show regionally fluctuating climatic conditions at these lakes since the end of the Last Glacial Maximum. First, a shrub-steppe developed under low effective moisture and possibly cold conditions from circa ~19,000–14,800 cal BP after the retreat of the glaciers. A gradual increase in woodland taxa until 11,500 cal BP suggests a steady rise in summer temperatures and in effective moisture, although still below modern values (De Porrás et al. 2014). After 11,500 cal BP, open canopy woods developed on the Andean mountain range and a transition from steppe to woodland (ecotone) on the leeward (east) side of the mountains (De Porrás et al. 2014). Seasonal cycles, similar to those at the present, were probably established at this point (Méndez et al. 2009). Between ~8,000 and 3,000 cal BP temperatures and effective moisture rose to their maximum values as indicated by the maximum eastward expansion of the woodland steppe ecotone (De Porrás et al. 2012). Highly variable conditions are recorded in CWP during the last 3,000 years (De Porrás et al. 2012, 2014), including a significant dry phase between 3,000 and 2,000 cal BP which may have affected the mobility cycles of the inhabitants (Méndez and Reyes 2008; Méndez et al. 2016a).

The archaeological sites

The El Chueco I (EC1) cave (44°29'36"S; 71°11'13"W) is located in the extra-Andean steppe plains at 914 m a.s.l. (Fig. 1), an important landmark (Fig. 2; Reyes et al. 2009). The cave is 12.8 m long, 7.5 m wide and 4 m high, with two opposed entrances, one facing southwest and the other to the east (Reyes et al. 2006). It is characterized by a sequence of 13 occupational events that are statistically indistinguishable from averaged radiocarbon dates between 11,500 and 180 cal BP (Méndez et al. 2016a). These can be organized into four occupational periods (Méndez et al. 2011, 2016b). The occupation identified during the Pleistocene-Holocene transition (~11,500 cal BP) was brief and characterized by one stone tool and charcoal specks restricted to one sector (Méndez et al. 2011). It fits the expectations of an exploration phase characterized by low visibility and a low density of easily available but rapidly discarded (expedient) stone artefacts (Binford 1979; Borrero and Franco 1997). There are also four separate occupational events between 10,050 and 8,500 cal BP (Méndez et al. 2016a), with more stone tools, although no faunal remains (Méndez et al. 2011). Among the stone materials identified is obsidian, an indicator of high mobility and/or broad scale interaction networks (Méndez et al. 2012). Five occupational events were dated between 6,900 and 5,400 BP, all characterized by brief activities and low intensity discard, although including faunal material, primarily composed of guanaco, suggesting the processing of whole carcasses. A final late Holocene period between 3,200 and 180 cal BP shows at least three

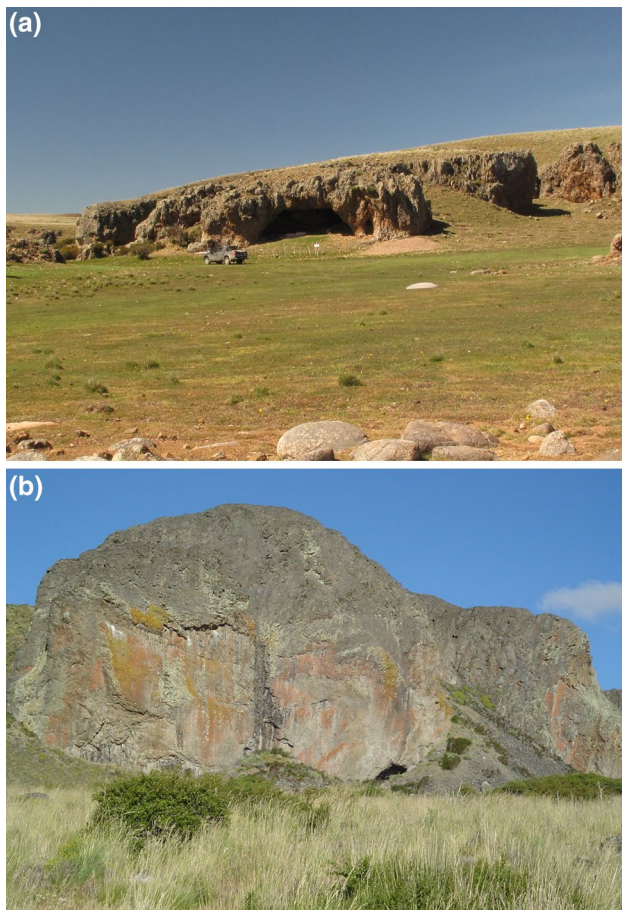


Fig. 2 View of the sites and the surrounding vegetation. **a** EC1; **b** BN1

undifferentiated overlapping events. There is a significant increase in faunal evidence, while the frequency of stone material diminishes slightly. Raw materials are of a lower quality, which is consistent with a more extended occupation of the local area (Méndez et al. 2016a). On the basis of faunal evidence from the middle and late Holocene levels, it has been suggested that site use was restricted to the summer season (Méndez et al. 2011).

The Baño Nuevo 1 (BN1) cave site (45°17'S, 71°32'W) is located in the basin of the river Ñirehuao, at 750 m a.s.l. (Fig. 1) on a basaltic butte of the extra-Andean steppe plains (Fig. 2). The cave is 20 m long, 4 m wide and 2.5 m high, facing south. Hunter-gatherers occupied the site since the beginning of the Holocene (Mena et al. 2000, 2003) as indicated by a minimum of 28 statistically indistinguishable occupational events dated between 11,100 and 3,000 cal BP (Mena and Stafford 2006). The early occupations, dated between 11,100 and 8,800 cal BP, are characterized by small assemblages of stones and few faunal remains, mainly consisting of guanaco bones (Velásquez and Mena 2006; García 2007). As in EC1, obsidian remains all through the

excavated sequence suggest that people were very mobile over several hundred kilometres (Méndez et al. 2012). However, the most remarkable features are the remains of ten human individuals directly dated to a statistically indistinguishable time span between 10,180 and 9,920 cal BP (Reyes et al. 2012). The disturbance from the funerary activities on the site made recognition of stratigraphic layering difficult in some parts of the cave, thus limiting the sediment sample selection, especially in the middle Holocene component (Mena and Stafford 2006; García 2007). As for the second phase, dated between 8,800 and 5,660 cal BP, the faunal assemblage shows continuity in the dominance of *Lama guanicoe* remains. It is interesting to note the presence of layers of plant remains, mainly grasses and sedges, which were possibly used for prepared work floors as suggested by their association with faunal remains (Velásquez and Mena 2006). Due to the complex stratification it is difficult to exactly identify the stone assemblage for this period, though it was probably abundant (García 2007). Finally, a third phase, dated between 5,660 and 3,100 cal BP, showed an increase in stone material (García 2007) and in guanaco remains, occasionally with signs of butchering (Velásquez and Mena 2006). Artefacts made of wood, shell and animal fibres were also recorded from the cave. The archaeological assemblages of cave BN1, including the funerary contexts, indicate that the site was repeatedly occupied throughout the sequence and that many different activities were carried out there, with an overall continuity of material remains (Mena and Stafford 2006).

Methodology

Excavations at EC1 and BN1 were done using geoarchaeological techniques to recognise the stratigraphic units (Mena and Stafford 2006; Méndez et al. 2011). The locations of all distinguishable archaeological remains were recorded. Different sampling strategies were used at the two sites, since they resulted from different research projects. In the case of BN1, sampling consisted of the extraction of sediment from the centre of seven excavated units in different stratigraphic layers (Table 1; Fig. 3), reaching a maximum depth of 106 cm at Unit 6C. At EC1, a flotation column 20×20 and 210 cm deep was extracted from Unit C2. Samples were recovered from the entire stratigraphic section (Table 2; Fig. 3). Additionally, features detected at both sites were individually sampled (Tables 1, 2). Therefore, the plant macroremains from the stratigraphic samples should be regarded as indicative of the dispersed material contained in the matrix as a result of the different activities and occupation events at the levels where they occurred. The material recovered from the archaeological features, on the other hand, constitutes the remains from specific events or

Table 1 The samples from the El Chueco 1 (EC1) site (age data according to Reyes et al. 2006; Méndez et al. 2011)

Chronology	Unit	Depth (cm)	Description	Vol. (l)	Age (cal BP)		
Possible historic component		0–10		1.0			
		10–20		1.0			
		20–30		1.0			
		30–40		1.0			
Late Holocene	C2	40–50		1.0	2,730–2,360		
		50–60		1.0			
		60–70		1.0			
		70–80		1.0			
		80–90		1.0			
		90–100		1.0			
		100–110		1.0			
Middle Holocene 2		110–120		1.0			
		120–130		1.0			
Middle Holocene 1		130–140		1.0			
		140–150		0.9			
Hiatus		150–160		0.6			
		160–170		0.9			
Early Holocene 2		170–180		1.0			
		180–190		0.55			
Early Holocene 1		190–200		0.6			
		200–210		1.0			
Subtotal column				19.55			
Late Holocene	B (–1) C2 C (–2) C (–1) C (–2) B2 C (–2) D (–2)	40–50	Concentration of rodent bones	0.45			
		50–60	<i>Feature E</i> : hearth	1.4			
		60–70	<i>Feature F</i> : hearth	1.0			
		50–60	<i>Feature G</i> : concentration of rodent bones	0.9			
		60–70	<i>Feature G</i> : concentration of rodent bones	1.35			
		64 (60–70)	<i>Feature a</i> : hearth	0.8			
		80–90	<i>Feature I</i> : hearth	5.5	2,710		
		80–90	<i>Feature I</i> : hearth	1.6			
		80–90	<i>Feature I</i> : hearth	0.5			
		80–90	Concentration of rodent bones	1.45			
		Middle Holocene 2	B (–2) A (–1) B (–2)	110–120	<i>Feature K</i> : hearth	3.4	5,396
				120–130	<i>Feature L</i> : hearth	1.2	
				120–130	<i>Feature M</i> : hearth	0.7	
Middle Holocene 1	A2 A (–1)	130–140	<i>Feature C</i> : hearth	1.8	6,780 (6,900–6,660)		
		140–150	<i>Feature N</i> : hearth	0.4			
Hiatus	B (–2)	150–160	<i>Feature O</i> : concentration of charcoal	0.06			
Early Holocene 2	B (–1) B (–2)	160–177	<i>Feature P</i> : concentration of charcoal	0.5			
		180–190	<i>Feature R</i> : hearth	0.9			
Early Holocene 1	A (–1) A (–1)	190–200	<i>Feature S</i> : concentration of charcoal	0.4			
		190–200	<i>Feature T</i> : ashes and charcoal	0.65	10,175		
Terminal Pleistocene	A2 A2	200–210	Soil sample	2.1	11,760–11,260		
		200–210	Soil sample	2.0	11,760–11,260		
Subtotal features				29.06			
Total El Chueco 1				48.61			

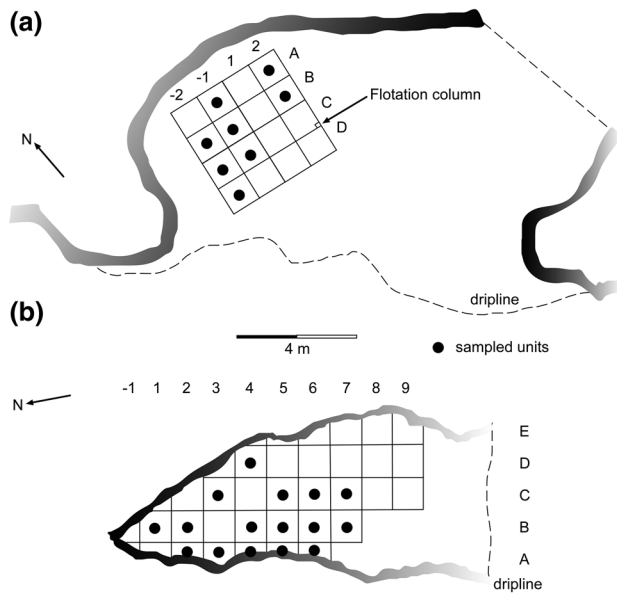


Fig. 3 **a** EC1, grid of 1 m² excavation units and positions of flotation samples; **b** BN1, grid of excavation units and positions of flotation samples

successions of events of restricted spatial extent at the site. At EC1, the sediment samples came from stratigraphic layers and 15 features, amounting to 48.61 L sediment, while at BN1, the samples were extracted from specific stratigraphic layers, in addition to eight sampled features, giving 62.07 L sediment.

For the purpose of this paper, besides the occupational event at the Pleistocene to Holocene transition (11,500 cal BP) at EC1, data were organized according to the following periods of time: (1) early Holocene—BN1: 10,750–8,800 cal BP, EC1: 10,050–8,500 cal BP; (2) middle Holocene—BN1: 8,800–5,660 cal BP, EC1: 6,900–5,400 cal BP; and (3) late Holocene—BN1: 5,660–3,100 cal BP, EC1: 3,200–180 cal BP.

The recovery of the plant macroremains was done using water flotation techniques with a machine that separated the botanical material from the matrix with a continuous flow of water (Watson 1976). The sample volumes were measured to establish their size and thus standardize the results. The sorting of the plant material was done with a stereomicroscope using 10× to 20× magnification. Based on preservation through carbonization (Miksicek 1987), only charred remains were considered for this study. Considering that both sites are caves, wind may have introduced uncharred plant remains into them; therefore we chose to work with a secure archaeobotanical context in order to discuss gathering strategies among steppe hunter-gatherers. There are no natural causes for fires here (Méndez et al. 2016a), and therefore of naturally charred seeds or fruits. Therefore, until taphonomical studies evaluating the natural deposition of

plant remains for both sites are available, we shall not infer anything from desiccated plant remains.

For the taxonomic identification, we built up a seed and fruit reference collection of the vegetation surrounding the sites. Archaeological reference collections and specialized bibliographies (Muñoz 1966; Martin and Barkley 1973; Matthei 1995; Fundación Península Raulí 2001; Rapoport et al. 2003) were also consulted. In order to suggest which environments were used, it was necessary to determine which plants were potentially available in the locality. Therefore, botanical land surveys available for BN1 (Rojas 2006 unpublished manuscript) and EC1 (Maldonado 2014 unpublished manuscript) were consulted, and complemented with existing broader bioclimatic and vegetation descriptions (Gajardo 1993; Luebert and Pliscoff 2006) to determine which plants were locally available. We consider non-local plants to be those not listed in these surveys and which are not mentioned in the bioclimatic and vegetation descriptions of the Mediterranean-temperate *Festuca pallelescens* and *Mulinum spinosum* steppe environment. We also used this information to distinguish the spatial distribution of plants, which may vary from being concentrated and restricted to certain microzones, or available in large stands and extensively distributed across the landscape (Rossen and Ramírez 1997).

We applied qualitative and quantitative approaches to process the archaeobotanical information and to establish comparable parameters (Popper 1988). Density of remains was calculated from the volume of charred plant remains per litre, as cp/l (Miller 1988). Richness indicates the number of plant taxa in the assemblage, the number of taxa identified per sample (Lepofsky and Lyons 2003). A ubiquity score (US), expressed in percentage, was also estimated, in order to determine the number of samples in which each taxon was present out of the total number of samples, so as to assess their presence in the studied contexts (Popper 1988).

Results

Table 3 shows the relative frequencies of stratigraphic and feature based plant remains given as absolute quantities by site and by time period, where we can see that from the EC1 site 712 carbonized plant remains were recovered, whereas 364 were recovered from BN1. All identified plant remains were seeds, but some unidentified fruits were present in some samples. In the stratigraphic samples from EC1, higher frequencies of plant remains were recovered from the late Holocene samples (64.1%), followed by the early Holocene 1 (28.2%). From the features at this site, the samples from the middle Holocene yielded the highest percentage of macroremains (56.4%). As for the stratigraphic samples from BN1, higher frequencies were observed for the early (69.5%) and late periods of time (30.5%), while

Table 2 The samples from the Baño Nuevo 1 (BN1) site

Unit	Layer	Depth (cm)	Feature	Vol. (l)	Periods of time	
1B	3			1		
	4			1		
	5			1		
2A	3			1		
	4			1		
	5			1		
2B	4			1		
3A	5			1		
3C	4			1		
4A	4			1		
	5			1		
4B	2			1	Late	
	3			1		
	4			1		
4D	5			1		
	2			2	Late	
	3			1.36	Late	
5B	3	24–34		1.75	Late	
	3–1	50		1.65		
5B(5A)				1.7		
5C	5			1.5		
	2			1.05	Late	
	4B			2.25		
6B	5			2		
	1	31		1.65	Late	
	3 (3)	57		1.8	Early	
6C	4B	75		1.75		
	3	Level 2		0.71	Late	
	3	Level 1		0.75	Late	
7B	4A	69		2	Early	
	4B	76		1.45	Early	
	5 (3)	106		2		
7C	1			1.2	Late	
	2			1	Late	
	3			1		
7C	3	46		1		
	3	69–75		1	Early	
	5	100		1		
	Subtotal stratigraphic samples				51.57	
	1B	4		Below individual 7	0.7	Early
4B	4		Combustion structure	0.2	Early	
4D	3		<i>Feature 4</i> : concentration of plant remains	2.1	Middle	
	3		<i>Feature 5</i> : concentration of plant remains	1.25	Early	
5B (5A)	3	43	<i>Feature 11</i> : concentration of plant remains	1.65	Middle	
5C	3		<i>Feature 13</i> : hearth	1.65	Early	
6C	3		<i>Feature 1</i> : hearth	0.95	Late	
7C	4–5		<i>Feature 4</i> : individual 6	1	Early	
7C		60	<i>Feature 5</i> : hearth	1	Early	
Subtotal features				10.5		
Total Baño Nuevo 1				62.07		

Table 3 Absolute frequencies and percentages of the plant macroremains recovered from the stratigraphic samples and features at the EC1 and BN1 sites

Sites	Periods of time	EC1		BN1	
		<i>n</i>	%	<i>n</i>	%
Stratigraphic samples	Early Holocene	11	28.1	107	69.5
	Middle Holocene	1	2.6	0	0
	Late Holocene	25	64.1	47	30.5
	Subtotal stratigraphic samples	37	100	154	100
Feature samples	Pleistocene–Holocene transition	6	0.9	–	0
	Early Holocene	10	2.9	171	81.4
	Middle Holocene	380	53.4	5	2.4
	Late Holocene	280	42.8	34	16.2
Subtotal feature samples	676	100	210	100	
Total		713	–	364	–

in the feature samples, higher frequencies of plant material corresponded to the early Holocene samples (81.4%).

The late Holocene stratigraphic samples from EC1 showed a greater density of macroremains (4.2 cp/l) than the others. The middle Holocene feature samples had a greater density (50.7 cp/l) than the rest (Table 4). The general overview, however, shows that the densities are low, fluctuating between 1 and 4 cp/l. Regarding richness, the highest value is 12 taxa from the late Holocene, and less from the middle Holocene with seven taxa, the early Holocene with two taxa and the Pleistocene–Holocene transition with one taxon, making a total of 13 taxa for the site.

The greatest density of macroremains in the stratigraphic samples from BN1 came from the early Holocene, at 17.1 cp/l from the whole assemblage, whereas for the features, the late Holocene part is noteworthy at 35.8 cp/l (Table 4). A total of 18 taxa were identified from the site (Table 4). An assemblage of taxa recurs, with Apiaceae, *Berberis* sp., Chenopodiaceae, Cyperaceae, Ericaceae, Fabaceae, *Fragaria chiloensis*, *Galium* sp. and Poaceae from the early and late Holocene occupation periods, which also have a greater richness of seed remains (Figs. 4, 5). According to the occupational period, there was greater taxon richness in the early Holocene samples, with 17 taxa, than in

the late Holocene ones with ten taxa and especially in the middle Holocene material with one taxon, perhaps due to allocation problems with some samples.

The distribution of plant taxa in the ECI column has *Galium* sp. (*n* = 3) and Lamiaceae (*n* = 1) in the early Holocene (Table 5). In the middle Holocene assemblage, only one seed, unidentifiable with our technique, was recorded. In the late Holocene samples, two types of Brassicaceae (*n* = 3 and *n* = 11) were found, in addition to Chenopodiaceae (*n* = 1) and Lamiaceae (*n* = 8). The seed record of the EC1 features for the Pleistocene–Holocene transition is composed only of *Galium* sp. (*n* = 2), which also appears in the features associated with the early Holocene (*n* = 3). In the middle Holocene assemblage, there is a notable presence of Lamiaceae (*n* = 313) and a lesser frequency of *Galium* sp. (*n* = 19), Poaceae (*n* = 4) and Brassicaceae (*n* = 2), in addition to *Berberis* sp., Malvaceae and Polygonaceae. Finally, in the late Holocene material, the features contained seeds of Chenopodiaceae (*n* = 141), Brassicaceae 1 (*n* = 53), Lamiaceae (*n* = 25), *Galium* sp. (*n* = 14), *Carex* sp. (*n* = 7), *Berberis* sp., Brassicaceae, *Cyperus* sp., *Phacelia* sp., Poaceae, Polygonaceae and *Scirpus* sp. (Table 5).

The seed record for the stratigraphic samples from the early Holocene of BN1 contained *Galium* sp. (*n* = 16),

Table 4 Absolute frequencies, densities (cp/l) and taxon richnesses of the plant macroremain records from the EC1 and BN1 sites, by period of time. S = stratigraphic, F = feature

Site	Pleist./Holocene transition		Early Holocene				Middle Holocene				Late Holocene			
	EC1		EC1		BN1		EC1		BN1		EC1		BN1	
	S	F	S	F	S	F	S	F	S	F	S	F	S	F
<i>n</i>	0	6	11	10	107	171	1	380	0	5	25	280	47	34
Density (cp/l)	1.46		4.9		13.4		30.3		1.33		14.6		5.3	
Richness	0	1.46	3.49	4.08	17.09	29.48	2.04	50.67	0	2.38	4.17	18.73	3.5	35.79
	1		2		17		7		1		12		10	
	0	1	2	1	7	14	0	7	0	1	4	12	6	7

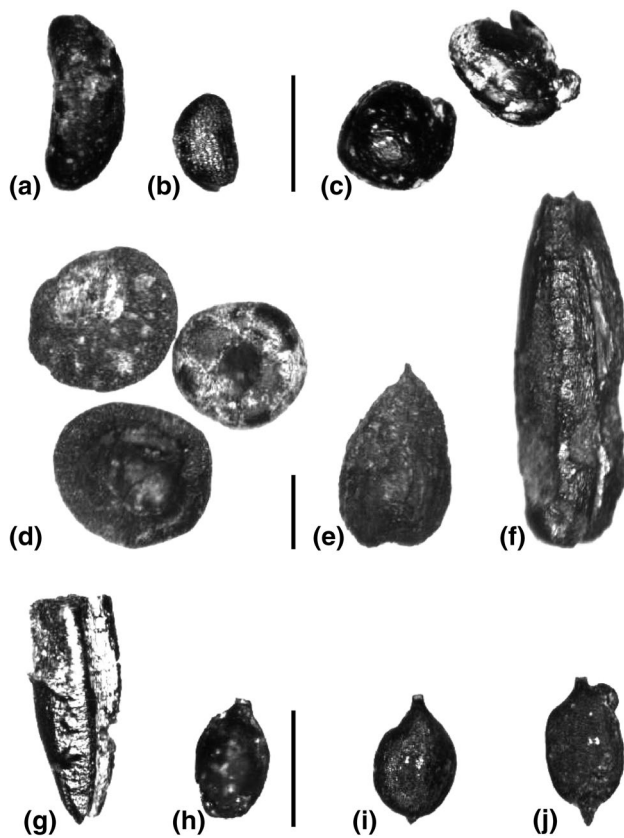


Fig. 4 The most common seeds recorded from CH1. **a** *Berberis* sp.; **b** Brassicaceae; **c** Chenopodiaceae; **d** *Galium* sp.; **e** Lamiaceae; **f**, **g** Poaceae; **h** *Scirpus* sp.; **i** *Carex* sp.; **j** *Cyperus* sp. Scale 1 mm

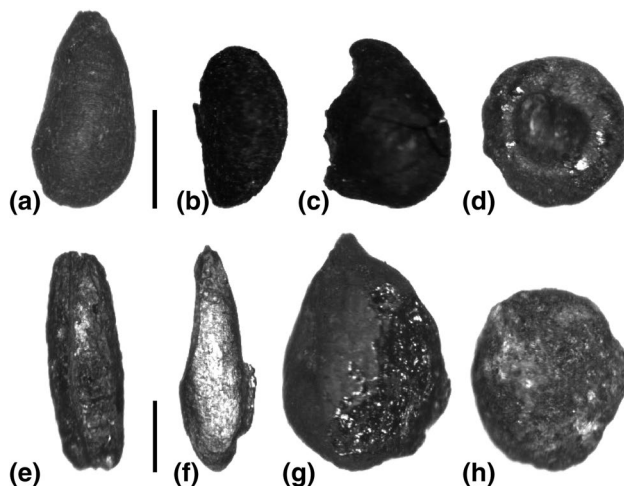


Fig. 5 The most common seeds recorded from BN1. **a** *Berberis* sp.; **b** Ericaceae; **c** *Fragaria chiloensis*; **d** *Galium* sp.; **e**, **f** Poaceae; **g**, **h** Unidentified fruits. Scale 1 mm

Ericaceae (n=11), Poaceae (n=9), *Rubus* sp. (n=3), *Berberis* sp. (n=2), *Fragaria chiloensis* (n=2), unidentified fruits (n=2) and Convolvulaceae (n=1) (Table 5). No

evidence was obtained from the middle Holocene due to a lack of stratigraphic samples for this period, since there are only a few dated horizons here. Finally, in the late Holocene material, the seed record is composed of Brassicaceae (n=4), *Berberis* sp. (n=2), Ericaceae (n=3), *Fragaria chiloensis* (n=2), Fabaceae (n=1) and Poaceae (n=1). The taxa recorded in the BN1 early Holocene features are Apiaceae (n=10), Ericaceae (n=10), Poaceae (n=8), *Berberis* sp. (n=8) and *Galium* sp. (n=6), among others. As for the middle Holocene component, the only recorded taxon is *Galium* sp. (n=1). Finally, in the late Holocene, the recovered remains were Ericaceae (n=3) and Brassicaceae (n=2), in addition to single seeds of Apiaceae, Chenopodiaceae, Cyperaceae, *Galium* sp., and Poaceae.

Regarding the US for EC1 (Table 6), we can note the high ubiquity of *Galium* sp. (32.5%), followed by Lamiaceae (20%) and to a lesser extent Poaceae (12.5%) and Brassicaceae (10%). Comparing sample types, the stratigraphic samples show higher ubiquity for *Galium* sp. (7.5%) and Lamiaceae (7.5%), whereas the features show higher ubiquity for *Galium* sp. (25%), Lamiaceae (12.5%), Poaceae (12.5%) and Brassicaceae (7.5%). In the case of periods of time, *Galium* sp. has the highest US for the early Holocene (12.5%), while in the middle Holocene, Lamiaceae (10%) and Poaceae (7.5%) dominate. In the late Holocene assemblage, USs are higher for Brassicaceae, *Galium* sp. and Lamiaceae (7.5%).

In a general overview of the identified taxa from BN1, these are very few, with the highest, Ericaceae, having a US of 18%, followed by Poaceae (14%), *Berberis* sp. (12%) and *Galium* sp. (12%) (Table 7). The rest of the assemblage shows lower USs, indicating that their presence in the record is less common. Upon comparing the stratigraphic samples with those of the features, the former have a greater incidence of Ericaceae (12%) in the record, together with Poaceae (8%), *Berberis* sp. (6%), *Fragaria chiloensis* (4%) and *Galium* sp. (4%). Regarding the features, the most frequent is *Galium* sp. (8%), followed by Apiaceae, *Berberis* sp., Ericaceae and Poaceae (6%). According to each period of occupation, Ericaceae has the highest US in the early period (10%), followed by the late Holocene part (8%). Poaceae (10%), *Berberis* sp. (8%) and *Galium* sp. (8%) are also important in the early Holocene.

Discussion

Hunter-gatherer occupations in the study area date back to at least 11,500 cal BP (Méndez and Reyes 2008). Understanding the variation in vegetation evidence throughout the Holocene from key stratified sites is mandatory for properly assessing subsistence choices of mobile groups which repeatedly occupied certain areas in the steppe of

Table 5 Absolute frequencies of the plant taxa identified from the EC1 and BN1 sites, with period of time and sample type. S = stratigraphic, F = feature

Period of time	Pleist/ Holoc. transition		Early Holocene				Middle Holocene				Late Holocene			
	EC1		EC1		BN1		EC1		BN1		EC1		BN1	
	S	F	S	F	S	F	S	F	S	F	S	F	S	F
Scientific name														
Alstroemeriaceae						1								
Apiaceae						10								1
cf. Apiaceae						1								
<i>Berberis</i> sp.				2	8		1				2	2		
Brassicaceae							2				3	2	4	2
Brassicaceae 1											11	53		
Calceolariaceae						2								
<i>Carex</i> sp.												7		
Chenopodiaceae						2					1	141		1
Convolvulaceae				1										
<i>Cyperus</i> sp.												1		
Cyperaceae						1								1
<i>Eleocharis</i> sp.						1								
Ericaceae				11	10								3	3
Fabaceae														1
<i>Fragaria chiloensis</i>					2	2								2
<i>Galium</i> sp.		2	3	3	16	6	19	1			14			1
Lamiaceae			1				313			8	25			
<i>Libertia</i> sp.						1								
Malvaceae							1							
<i>Phacelia</i> sp.												2		
Poaceae				9	8		4				5	1	1	
Polygonaceae							1				2			
Portulacaceae						1								
<i>Rubus</i> sp.				3										
<i>Scirpus</i> sp.												4		
<i>Uncinia</i> sp.						1								
Unidentified fruit					2	13						3		
Unidentified		4	3	5	35	25	39			1	10	19	3	
Unidentifiable			4	2	26	78	1		4	1	9	15	21	

CWP. Palaeoenvironmental reconstructions for the region indicate no major changes in the distribution of vegetation since approximately 8,000 cal BP (Markgraf et al. 2007; De Porrás et al. 2012, 2014) and the possible establishment of seasonality similar to that of the present day from 11,500 cal BP (Méndez et al. 2009). The only variations relate to fluctuations of the limits of the transition zones, due to changes in the effective moisture (De Porrás et al. 2012). These changes in the position of the woodland-steppe ecotone would have had only a minor impact on the steppe vegetation communities in the places where the studied archaeological sites are located. Hence, the plant communities associated with the steppe environment and micro-climates detected near these sites would have been similar to those of current conditions.

In order to identify locally and regionally useful resources, the information from the vegetation surveys around each site by botanists (Rojas 2006 unpublished manuscript; Maldonado 2014 unpublished manuscript) was compared with the taxa identified from BN1 and EC1. Four out of ten taxa at EC1 and ten out of 21 taxa at BN1 are presently found in the area surrounding the sites. Among these local plants, three taxa have a restricted distribution at EC1, *Berberis* sp., *Carex* sp. and *Cyperus* sp. Four taxa have a restricted distribution at BN1, *Berberis* sp., *Carex* sp., Ericaceae and *Fragaria chiloensis*. In the EC1 area, these restricted microzones are found 8 km away and 6 km from the BN1 site. The plants with restricted distributions include: (1) shrubs such as *Berberis* sp. and Ericaceae, which form

Table 6 Ubiquity scores in percent of plant taxa from EC1 site

Taxa	Sample type			Period of time				
	Column	Feature	Total	Pleist.–Holoc. transition	Early Holocene	Middle Holocene	Late Holocene	Total
<i>Berberis</i> sp.		5	5			2.5	2.5	5
Brassicaceae	2.5	7.5	10			5	5	10
Brassicaceae 1	5	2.5	7.5				7.5	7.5
<i>Carex</i> sp.		2.5	2.5				2.5	2.5
Chenopodiaceae	2.5	2.5	5				5	5
<i>Cyperus</i> sp.		2.5	2.5				2.5	2.5
<i>Galium</i> sp.	7.5	25	32.5	5	12.5	5	7.5	32.5
Lamiaceae	7.5	12.5	20		2.5	10	7.5	20
Malvaceae		2.5	2.5			2.5		2.5
<i>Phacelia</i> sp.		2.5	2.5				2.5	2.5
Poaceae		12.5	12.5			7.5	5	12.5
Polygonaceae		5	5			2.5	2.5	5
<i>Scirpus</i> sp.		2.5	2.5				2.5	2.5
Unidentified fruit		2.5	2.5				2.5	2.5

Table 7 Ubiquity scores in percent of plant taxa from BN1 site

Taxa	Sample type			Period of time			
	Column	Feature	Total	Early Holocene	Middle Holocene	Late Holocene	Total
Alstroemeriaceae		2	2	2			2
Apiaceae		6	6	4		2	6
<i>Berberis</i> sp.	6	6	12	8		4	12
Brassicaceae	2	2	4			4	4
Calceolariaceae		2	2	2			2
Chenopodiaceae		4	4	2		2	4
Convolvulaceae	2		2	2			2
Cyperaceae		4	4	2		2	4
<i>Eleocharis</i> sp.		2	2	2			2
Ericaceae	12	6	18	10		8	18
Fabaceae	2		2			2	2
<i>Fragaria chiloensis</i>	4		4	2		2	4
<i>Galium</i> sp.	4	8	12	8	2	2	12
<i>Libertia</i> sp.		2	2	2			2
Poaceae	8	6	14	10		4	14
Portulacaceae		2	2	2			2
<i>Rubus</i> sp.	2		2	2			2
<i>Uncinia</i> sp.		2	2	2			2
Unidentified fruit	2	2	4	4			4

communities on hillsides and near water sources (Gajardo 1993); (2) plants from wet environments like *Carex* sp. (Matthei 1995; Hoffmann 1998; Hoffmann et al. 1998) and (3) plants growing on woodland floors and in meadows, like *Fragaria chiloensis* (Hoffmann et al. 1998). Plant resources with an extensive distribution at EC1 such as Brassicaceae, Poaceae and *Galium* sp., and at BN1 such as Apiaceae,

Brassicaceae, *Bromus* sp., Portulacaceae and *Galium* sp., are part of the floral associations of the steppe landscape (Gajardo 1993; Matthei 1995; Luebert and Plischoff 2006).

The taxa not detected in the plant surveys that were found in the record for EC1, were Chenopodiaceae, which has an extensive distribution, and Lamiaceae and Polygonaceae, the distribution of which cannot be determined. At BN1 the taxa

not found include herbaceous plants with extensive distributions (Calceolariaceae, Chenopodiaceae and Convolvulaceae) and others with restricted distributions (*Eleocharis* sp., *Scirpus* sp., *Uncinia* sp., *Libertia* sp. and *Rubus* sp.), in addition to plants whose distribution type cannot be determined, given that they were only identified to family level (Fabaceae, Lamiaceae, Malvaceae and Portulacaceae).

In general terms, more herbaceous plants than shrubs were found in the samples (Table 6). The former are common in diverse environments including steppes and have an extensive distribution. Trees and shrubs such as *Rubus* sp., *Berberis* sp. and Ericaceae are concentrated in specific areas where locally distributed plant communities grow on hillsides and near watercourses (Gajardo 1993). These two types of restricted environments are found near both archaeological sites. EC1 is located near minor tributaries of the river Cisnes (~8 km away) and near Lago El Shaman (~6 km away), whereas BN1 is located close to the river Ñirehuao (~6 km away) and small seasonal lakes.

Uses and seasonality

Although potential plant uses are constrained by biological factors, human behaviour plays an important role in defining the use of a resource (Ford 1979). In order to determine the possible uses of these plants, documentary sources were consulted. This information is given in Table 8. It distinguishes between useable parts, potential uses, their distribution and the period of fruit and seed production. Seven potential uses were identified, (1) as food, including the direct consumption of fruits, seeds or green leaves, as well as the production of flour and condiments; (2) as drinks such as fermentations, infusions or other non-fermented preparations; (3) as raw materials, including the use of plant fibres for baskets, rope, needles or other things; (4) as medicines; (5) as fuel; (6) as dyes and (7) for smoking. Some of these uses, however, should be regarded as less probable due to the restrictions imposed by frequent mobility in hunter-gatherer societies.

In some cases, the genus or species could not be determined, making it difficult to define the plant's properties and to accurately suggest fruit or seed seasonality. However, whenever fruit and seed production periods were established, they all coincided with summer. In the cases of *Berberis* sp., Ericaceae, *Fragaria chilensis* and *Libertia* sp., seasonality was extended to late spring. However, given the fact that fruits are generally produced in the spring or summer, it is worth noting that their visibility in the record is enhanced when compared to indicators of other seasons. This is also true for other archaeological bio-indicators at these latitudes such as faunas, which are biased towards these seasons and thus need to be considered cautiously.

Plant resource management during the Holocene

The earliest human evidence corresponds with a low-intensity occupation at EC1 during the Pleistocene–Holocene transition, interpreted as exploratory in the context of profound environmental changes (Méndez et al. 2011). The seed record indicates low-density material represented by a single taxon consisting of *Galium* sp. This finding indicates the presence of a herbaceous plant with an extensive distribution that produces seeds in summer. The charred state of the macroremains indicates a fire started by occupants of the cave rather than a natural occurrence, when considered alongside other contextual evidence (Méndez et al. 2016a). However, any attempt to determine its function would be highly speculative in view of the meagre sample. The possibility of the vertical migration of intrusive material from the upper levels should not be completely ruled out. The plant survey of the upper Cisnes valley does not record its presence, although descriptions of the steppe in floras identify *Galium* sp. in this biome (Luebert and Pliscoff 2006; Maldonado et al. 2011 unpublished manuscript).

An important much earlier late Pleistocene site with archaeobotanical data is Monte Verde II, ~14,600 cal BP, in the Chilean lake district (Dillehay 1997; Dillehay et al. 2008). It yielded an ample archaeobotanical record that indicates the use of local and non-local plants (Rossen and Ramírez 1997). Hunter-gatherers here used different environments, such as inland woodlands, the coasts and swamp areas (*mallín*). This implies that the routes used by the inhabitants went through the Maullín basin to reach these different microzones or to trade with other groups (Dillehay et al. 2008). This seasonal evidence of fruits, seeds and algae shows long periods spent at the site, where the use of the coastal areas complemented with plants from inland has been interpreted as a sign of more permanent occupation (Rossen and Ramírez 1997; Dillehay et al. 2008).

The early Holocene events of EC1 are characterized by recurrent short separate occupations, with no faunal evidence, although with a greater stone discard rate. Low-intensity occupations yielded obsidian from two different distant sources (Méndez et al. 2012), which suggest broad movements of people over overlapping ranges in large scale interaction. The seed record is of low density and low richness, given that only two taxa were identified, *Galium* sp. and Lamiaceae. Both were absent from the survey around the site, despite the fact that floral descriptions confirm these plants in the steppe environment (Luebert and Pliscoff 2006). They are herbaceous, and it is known that *Galium* sp. produces seeds in summer and has an extensive distribution, although in the case of the Lamiaceae, seasonality cannot be determined with precision. The potential use of *Galium* sp. for dye has been recognized. In the case of Lamiaceae,

Table 8 Description of the vegetation types, distribution, fruit/seed seasonality, useful plant parts and potential uses of the plant taxa from the EC1 and BN1 sites. Distribution: E=extensive, R=restricted; potential uses. *EF* edible/food, *S* food sub-product, *I* infusion, *C* condiment, *M* medicinal, *D* dye, *Al* alkaloids, *SM* for smoking, *RM* raw material, *F* fire/combustion, *B* basketry. Fruit seasons based on Hoffmann et al. 1998; Hoffmann 1998; Guerrido and Fernández 2007. Table references: Chapman 1998; Ciampagna and

Capparelli 2012; Gay 2010; Guerrido and Fernández 2007; Gusinde 1982; Hoffmann 1998; Hoffmann et al. 1998; Latcham 1936; Martínez-Croveto 1968, 1982; Martinic 1991, 1995; Mösbach 1999; Moreno 1969; Muñoz et al. 1981; Musters 1964; Pardo and Pizarro 2005a, b, 2013; Ragonese and Martínez-Croveto 1947; Rapoport and Ladio 1999; Rapoport et al. 2003; Schmeda-Hirschmann et al. 1999; Silva et al. 2004

Taxon	Habit	Distribution	Fruiting season	Useful part	Potential uses
Alstroemeriaceae	Herb	E	Summer	Rhizome	EF, S
Apiaceae	Herb	R	–	Roots	EF, I, C
				Leaf	EF, I, C, M
<i>Berberis</i> sp.	Shrub	R	End of spring–summer	Fruit	EF, S, M, D, Al, SM
				Leaf	M, SM
				Roots	D, M
				Wood	RM, M C
				Thorn	RM
Brassicaceae	Herb	E	–	Seed	EF
				Leaf	EF
<i>Carex</i> sp.	Herb	R	Summer	Stem/fibre	B
					RM, F
Calceolariaceae	Herb	E	Summer	Root	D
Chenopodiaceae	Herb	E	–	Leaf	EF, M
				Root	M
Convolvulaceae	Herb	E	–	Leaf	EF
<i>Cyperus</i> sp.	Herb	R	Summer	Tuber	EF
				Stem/	B
				Fibre	RM, F
Cyperaceae	Herb	R	–	Rhizome	EF
				Stem/fibre	B, RM, F
<i>Eleocharis</i> sp.	Herb	R	Summer	Stem/fibre	B, RM, F
Ericaceae	Shrub	R	Spring–summer	Fruit	EF
				Wood	RM, F
Fabaceae	Herb/shrub/tree	–	–	Leaf	M
				Rhizome	EF
				Seed	EF
				Fruit	EF
<i>Fragaria chiloensis</i>	Herb	R	Spring–summer	Whole plant	M
				Fruit	EF
<i>Galium</i> sp.	Herb	E	Summer		D
Lamiaceae	Herb	–	–	Leaf	I, M, C
<i>Libertia</i> sp.	Herb	R	End of spring–summer	Rhizome	M
Malvaceae	Herb	–	Summer		No record
<i>Phacelia</i> sp.	Herb	–	Summer		M, F
Poaceae	Herb	E	Summer	Seed	EF
				Stem	EF, RM, F
Poaceae cf. <i>Bromus</i>	Herb	E	–	Seed	EF, S
				Soot	M
Polygonaceae	Herb/ shrub	–	–	Fruit	M
Portulacaceae		–	–		No record
<i>Rubus</i> sp.	Shrub	R	Summer	Fruit	EF
<i>Scirpus</i> sp.	Herb	R	–	Rhizome	EF
				Stem	EF
				Fibre	RM, F
<i>Uncinia</i> sp.	Herb	R	–		No record

various taxa with medicinal properties and the leaves of which are used to prepare infusions are known in the wider region.

Considering that BN1 shows the convergence of multiple activities including the making, use and discarding of stone tools, as well as butchering and consumption of ungulates, especially guanaco, one would expect to find evidence for the use of plant resources. As such, in the early Holocene occupation periods, a significant richness of taxa was recorded. Herbaceous taxa predominate; shrubs such as *Berberis* sp., Ericaceae and *Rubus* sp. were present to lesser extent. Also, plants with an extensive distribution in the area surrounding the site were detected, as well as plants found in more spatially restricted areas close by, approximately 6 km away, which coincided with the same shrubs noted above. The plants which were identified have a range of possible uses, such as for fuel, food, infusions, medicines, dyes or smoking, or as raw material for making various artefacts. Although isotopic studies of the early Holocene human remains found at BN1 suggest that their diet was based on a broad spectrum of steppe fauna of various sizes ($10.6 \pm 1.9\text{‰}$ for $\delta^{15}\text{N}$; Méndez et al. 2014), it should be considered that the averaged value of $-19.7 \pm 1.1\text{‰}$ of $\delta^{13}\text{C}$ is consistent with the direct consumption of C_3 plants. This idea is supported by the presence of edible plant taxa at the site, not overlooking the fact that they may have had other potential uses too. Also, abrasion and wear on the teeth of some of these individuals, in addition to the chipping of the tooth enamel, are suggestive of the consumption of seeds and fruits (Hillson 1996; Reyes et al. 2012).

On the one hand, the presence of various seeds and fruits appearing in late spring and summer suggests the use of the cave during these seasons. On the other hand, archaeofaunal indicators suggest the possible use of this site during the winter. The use of the two types of archaeological evidence allows us to suggest that the early Holocene occupation period would have been a series of coinciding occupations at BN1 in at least two seasons of the year, rather than prolonged use of the site. However, additional indicators of seasonality must be integrated in order to narrow down the possibilities for occupation times at the site (Monks 1981).

The seed record of Cueva de la Vieja, another multicomponent hunter-gatherer site spanning the whole Holocene in the Ñirehuao basin, 2.3 km from BN1, is composed of Amaranthaceae, Poaceae, *Scirpus* sp. and *Uncinia* sp., reflecting the use of local plants (Méndez et al. 2017). As seasonal indicators, seed and fruit remains would indicate the occupation of the site during the summer (Méndez et al. 2017).

A contemporary cave site further away is Cueva Casa de Piedra 7, in Perito Moreno National Park, Santa Cruz, Argentina, which has yielded a rich archaeobotanical record from three lines of evidence, macroremains, charcoal/wood and microfossils recovered from human coprolites

(Martínez et al. 2012; Caruso and Capparelli 2013 in; Ciampagna 2014), showing the consumption and use of fruits like *Empetrum rubrum*, *Gaultheria mucronata* and species within the Ericaceae, among other taxa. There is an important presence of herbaceous and woody plants (Caruso and Capparelli 2013 in Ciampagna 2014). The presence of fragments of *Empetrum rubrum* and *Gaultheria mucronata* leaves shows the consumption of these, maybe as food, medicine or both (Martínez et al. 2012).

A more intense occupation is observed at EC1 during the middle Holocene. High quality stone raw material and implements with bifacial blade technology coupled with a high rate of curation and recycling were found. Few archaeofaunal remains occurred; however, analyses concluded that whole carcasses were brought to the site and that their age profile indicates a summer occupation (Méndez et al. 2011). The richness of the seed assemblage increases in this period, with seven identified taxa, *Galium* sp. and Poaceae, with an extensive distribution, and Brassicaceae, Lamiaceae, Malvaceae and Polygonaceae, with an undetermined distribution. In addition to these herbaceous taxa, the bush *Berberis* sp. is also present. It produces edible fruit in summer and spring and is a good raw material for tools and ideal for fuel. This information needs to be compared with ongoing charcoal studies on the site. Other taxa identified to genus and family have potential uses as food, medicine, raw materials and also firewood.

According to the vegetation survey, *Berberis* sp. and *B. buxifolia* are found in the area surrounding the site and are thus considered to be local resources, approximately 8 km away, despite having a restricted distribution. Meanwhile, Brassicaceae, *Galium* sp. and Poaceae are also found extensively around the site. Although Lamiaceae and Malvaceae were not recorded in the survey around EC1, the specialized literature associates them with steppe environments (Luebert and Plischoff 2006).

From the middle Holocene occupations, BN1 yielded smaller archaeological assemblages, but allocation problems should not be ruled out as contributing to this picture. Archaeofaunal remains, dominated by guanaco bones, do not show clear spatial patterns and stone material includes more frequent multiple edge retouches (Velásquez and Mena 2006; García 2007). Only two features were recorded containing *Galium* sp. This herbaceous plant is extensively distributed and recognized for its use in dyes, and its presence would indicate summer occupations at this site.

Regionally, the Cueva de la Vieja site provided a low richness seed record, represented by *Berberis* sp. and *Festuca* sp. (Méndez et al. 2017), which reflects the use of local plant resources, while *Berberis* sp. indicates summer occupation. In Argentinean Patagonia, the middle Holocene record from Cueva Epuyán Grande produced an assemblage of local plants, with *Austrocactus* cf. *bertinii*,

Elymus erianthus, *Festuca* sp., *Stipa* sp., *Larrea divaricata* and Cactaceae, reflecting the selective gathering of a local cactus, *A. cf. bertinii* for its edible fruit, as well as its flexibility and absence of hard fibres (Crivelli et al. 1996a, b). This archaeobotanical assemblage is not only rich, but it also indicates plant processing in situ.

In the late Holocene, the series of overlapping occupational events at EC1 are characterized by the use of low quality stone implements, probably of local origin, as well as exotic tool stones (Méndez et al. 2011). The faunal material indicates the presence of complete carcasses, among which the presence of juvenile guanaco suggests summer occupations. Previous papers have proposed an extensive occupation of the area around the river Cisnes during the late Holocene (Reyes et al. 2009; Méndez et al. 2016a). This could be reflected in the seed record of EC1, given that it showed a higher density of remains and richness of taxa ($n = 13$), indicating a more intensive re-occupation of the cave. In fact, the late component corresponds to the period of greatest plant richness in the sequence. It is represented by herbaceous plants of both extensive distributions (Brassicaceae, *Galium* sp. and Poaceae) and restricted ones (*Carex* sp., *Cyperus* sp. and *Scirpus* sp.), in addition to plants of unknown distributions (Chenopodiaceae, Lamiaceae, *Phacelia* sp. and Polygonaceae) and a shrub, *Berberis* sp. The seed remains and the activities detected at this site suggest that the occupants used the local flora to satisfy their needs such as for food, for making artefacts, and as fuel.

The plant survey for the area of EC1 records the presence of Brassicaceae, Chenopodiaceae, *Galium* sp., *Phacelia* sp. and Poaceae. However, Lamiaceae and Polygonaceae are also common in steppe landscapes (Luebert and Plissock 2006). This calls attention to the absence of *Carex* sp., *Cyperus* sp. and *Scirpus* sp. in the local survey, though it is interesting to note that other taxa within the Cyperaceae, such as *Carex* sp., do appear in bioclimatic and vegetation descriptions of the steppe (Gajardo 1993; Luebert and Plissock 2006), including plants adapted to damp environments such as those found by the river Cisnes and Lago El Shaman.

In this period of time a more intensive occupation was observed at BN1. Complete carcasses of large ungulates, primarily guanaco, as well as spring and summer indicators were recorded (Velásquez and Mena 2006). There is, however, an overall decline in frequencies of stone tools (García 2007). The richness of plant taxa in the archaeobotanical record increases during this period. There is a dominance of herbs with an extensive distribution and specific cases of taxa of restricted distribution, including the shrubs *Berberis* sp. and Ericaceae, and the herbaceous plants Cyperaceae and *Fragaria chiloensis*, suggesting the use of hillsides near water sources and damp environments, both of which are present close to the site, ~6 km away. According to the results, these plants could have had various potential uses,

including for food, infusions, medicine, dye, fuel and for making artefacts. For more information about the probable uses of these plants, other archaeobotanical aspects should be studied, such as residue analysis, charcoal remains and the identification of other macroscopic remains, such as stems or leaves. This additional information may provide more information on the use of plant resources at this site. Finally, the seed remains indicate summer occupation of the cave, which is consistent with the seasonality suggested from the faunal material.

Previous analyses of the BN1 site have emphasized the continuity of the archaeological record between the three periods of occupation, rather than sharp contrasts or differences between them (Mena et al. 2000; Velásquez and Mena 2006; García 2007; Mena 2009). This situation is most probably explained by the location of the site and the relatively stable natural conditions offered by the cave at 750 m a.s.l. In this sense, it is interesting how the seed record shows a difference between the middle period and the other two periods of occupation at the site, especially in relation to its seasonal use, as well as sampling problems. Despite the major bias presented by working with materials that appear seasonally, the archaeobotanical evidence enables us to assess the dynamics of the use of plant resources there.

For the late Holocene, there is more archaeobotanical data from Patagonia. It remains a question whether this is a research bias due to the understudied archaeobotanical records of earlier sites, or if this represents an increase of this evidence at a regional scale due to more people and a greater site density (Borrero 2001; Miotti and Salemme 2004). Regionally, the seed record of the Cueva de la Vieja site is rich and shows the use of local plants of both extensive and restrictive distributions (Méndez et al. 2017). Other contemporary sites in the Aisén region, such as Punta El Monte, at the woodland/steppe transition, and the Alero Las Quemas rockshelter in the woodland, repeat a similar pattern and set of plants, which were used, *Berberis* sp., Brassicaceae, Cyperaceae, Fabaceae, Poaceae and Polygonaceae (Belmar 2011). The general impression is that the occupants of these sites used a set of locally available plants with many known uses.

Extra-regionally, in Argentina, the late Holocene occupation at Cueva Epuyán Grande (Crivelli et al. 1996a, b) shows a great accumulation of plant remains found in different activity areas within the cave, for cooking, for working and where the cactus fruit was processed (Crivelli et al. 1996b). In the Chubut region, at the Campo Moncada 2 site, spring-summer occupations were inferred, with an extensive use of plant resources (Pérez de Micou 1985–1987). Further south, at the Cerro Casa de Piedra 7 site, fragments of *Empetrum rubrum*, *Gaultheria mucronata* and Poaceae leaf and fruit epidermis were identified from a human coprolite (Martínez

and Agueddú 2012). The studies indicate a summer occupation of the site (Martínez and Agueddú 2012).

By comparing the archaeobotanical data from the EC1 and BN1 sites with those from other Patagonian sites in the Aisén region of Chile and in Argentina, we can establish seasonality along with the gathering of local plants. Botanical remains have also been used as indicators of access to other plant communities. In the case of the entire EC1 and BN1 occupational sequences, even considering those taxa with a wider distribution, all plant remains recovered were of taxa that grow in the surroundings of the site; hence, we conclude that plant resources reflect only local movements of human groups. Plants, particularly their fruits and seeds, were probably consumed whenever available, thus reflecting the specific areas where they were gathered. Thus, if they indeed represent occasional consumption, why were they brought to the site? The fruits and seeds in the records from these sites show not only that the plants were gathered (foraged) and consumed on site (Binford 1983), but also that they had enough significance to be brought to the sites, considering that such activities would be hard to detect (Yellen 1989).

The results obtained from this study show that parts of plants were brought into the sites, possibly in a complementary fashion that occurred during the movement of the group. In this sense, one possibility is that plant gathering occurred as a part of other activities, following the widely used concept of embedded behaviour for explaining the procurement of stones for making tools (Binford 1979). However, if plants were used not only as food but also to meet other needs, such as for medicine or dyes, it is possible to suggest that there were more deliberate provisioning strategies according to the use of the plant. It is also necessary to consider that some parts of plants may have been brought to the site accidentally, for example as part of other materials used for making artefacts. To address and explore this issue, it would be necessary to find out from charcoal studies which types of wood were used as fuel and from residue analysis which technologies were associated with obtaining and processing plants.

There is no indication of the way in which plant materials were processed in this case study; however, microscopic use and wear studies have proven useful in showing the use of some artefacts for obtaining and processing plants (Álvarez 2004; Cooper and Nugent 2009). Considering the nature of the results from the seeds found at these two sites, we may expect that tools were used for digging up roots, cutting stalks and branches, softening plant fibres and containers were used for gathering activities. Therefore, based on Tanaka's proposal (1998), it is possible to suggest that steppe plants did not have a preferential place in the subsistence of the occupants of EC1 and BN1. These plant products would be expected to have consisted of different types of foods, varying according to season, location, and/or environmental

changes. Instead, through the Holocene sequences at these two sites, the plants that were found correspond to supplementary foods because they were never consumed in abundance, but were added as a complement to protein and animal fat. This is consistent with the isotopic values in human bones from the early Holocene funerary assemblage of BN1 (mentioned above), as well as from other late Holocene specimens (average value of $20.7 \pm 1.6\text{‰}$ for $\delta^{13}\text{C}$ and $9.9 \pm 0.6\text{‰}$ for $\delta^{15}\text{N}$) analysed in the broader region as part of a regional isotopic ecology (Méndez et al. 2014).

Finally, the seed evidence has indicated a seasonal sequence of occupations at both sites, although this information still needs to be confirmed by other seasonality indicators. Even though at EC1 there is no faunal assemblage from the earlier periods of occupation, both the bone remains from the middle and late Holocene and the seed records throughout the sequence permit us to suggest the use of the cave in late spring and in summer. This is consistent with expected harsh winters with snow cover at 900 m a.s.l. in this latitude (Reyes et al. 2009). In the case of BN1, the faunal record, whenever available, has indicated the use of the cave during summer and spring (Velásquez and Mena 2006; Mena 2009), although winter occupations should not be ruled out, given the less changeable conditions there at lower altitude. Evidence of fruits and seeds, however, also indicates that BN1 was used in late spring and summer. In this sense, it is most probable that mobile societies occupied the eastern margins of the Andes of CWP mainly around the summer as suggested by assemblages that represent a series of multiple overlapping occupations, which do not permit us to distinguish events at smaller scales.

Conclusions

We have observed how the seed record varies at two steppe hunter-gatherer sites in central western Patagonia (CWP) with occupational sequences spanning the last 11,000 years. Although differences exist at each site, for instance the richness of activities in BN1 as opposed to the ephemeral occupational events at EC1, a similar set of plants was used at both places. The plants represented are associated with steppe environments, as well as with more restricted environments in the surroundings of both sites, on hillsides and by rivers and lakes. The taxa repeatedly found throughout the assemblages are *Berberis* sp., Brassicaceae, Chenopodiaceae, Cyperaceae, *Galium* sp., Poaceae and a series of unknown fruits. The analysed remains generally suggest and always in a complementary fashion, that at both sites plant consumption and use increased in time, represented by a great richness of the seed record, especially when comparing early stages of occupation with late ones.

Considering that BN1 has been defined as a multiple activity site and EC1 instead reflects the use of that cave for temporary, low-intensity activities, differences are expected at the site level. First, during the Pleistocene-Holocene transition, only EC1 presents meagre seed evidence consisting of *Galium* sp. It is difficult to establish with certainty the exact meaning of this finding, but the plant material was preserved charred, and thus considered to be the result of human activities. Towards the early Holocene, there is a greater richness of taxa and a high density of seed material from BN1 in contrast to EC1, which has a low density and richness of plant taxa when compared to its own record. The overall frequency of material remains in BN1, its features and the human remains suggests that this site was a significant place for the inhabitants and thus the frequency of plant remains is high. In general terms, from both sites, local herbaceous plants of extensive distribution were found, though in the case of BN1, local shrubs with restricted distribution were also recorded. During the middle Holocene, the situation is reversed; there was more intensive use of plants in EC1, with a high density and an increase in the richness of plant taxa, while the density of charred seed remains diminishes considerably in BN1, and only one taxon was recorded. The plants recorded are herbaceous and spatially dispersed. The only record of shrubs with restricted distribution is *Berberis* sp., which is present in EC1. Its potential uses include the consumption of seeds, fruits, leaves and rhizomes/roots and the use of parts of the plant for making tools, basketwork containers or even structures, as well as for fuel. The monocotyledons (grasses and sedges) may have been used for making basketwork and even structures such as matting. Finally, during the late Holocene, both sites show intermediate densities of charred seed remains and plant richness in their records. The more widespread use of landscapes after 3,000 cal BP is suggested by the record from the Cisnes valley (Reyes et al. 2009; Méndez et al. 2016a). From this period of time, plant remains include a selection of local resources, both of extensive and restricted distributions. As in the previous part of EC1, the varied potential uses are many, from consumption to raw materials and for fuel.

Archaeobotany, particularly seed analysis, has proven advantageous in creating a more complete picture of steppe hunter-gatherer sites in CWP. It can shed light on extensively debated issues in the context of this research area, such as the determination of the seasonality of occupations and discussion of the use of plant resources by these human groups, traditionally perceived just as hunters. Further systematic sampling and analysis of sediments and feature contents in the future may provide a more comprehensive view of the subsistence behaviour of the mobile peoples in Patagonia during the Holocene.

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