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Radiocarbon chronology of the early human occupation of Argentina

L. Prates [a,*], G. Politis [b], J. Steele [c]

[a] CONICET – División Arqueología, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Paseo del boque s/n, 1900 La Plata, Argentina
[b] INCUAPA-CONICET, Facultad de Ciencias Sociales, Universidad Nacional del Centro de la Provincia de Buenos Aires, Olavarría, Argentina
[c] AHRC, Centre for the Evolution of Cultural Diversity, Institute of Archaeology, University College London, United Kingdom

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ABSTRACT

This paper reports the compilation and initial analysis of a database of ^{14}C dates from archaeological sites in Argentina for the period 13,000 and 7000 ^{14}C BP. The spatial and temporal distribution of human occupation evidence during this period is surveyed, with discussion of potential sampling biases affecting the recognition of such sites in each region of Argentina. The archaeological signal of human occupation at the beginning of this period (13,000–11,000 ^{14}C BP) is suggestive but sparse, and weak. However, from about 11,000 ^{14}C BP there is a consistent archaeological signal. Most of the earliest occupation evidence comes from the eastern Pampas and from southern Patagonia. In the Chaco and Northeast regions, similarly early archaeological sites have not yet been detected. This contrast may reflect the actual distribution of early human occupation, but it may also reflect biased research effort and/or systemic factors affecting the visibility and level of preservation of the early archaeological record. In other regions such as the eastern slope of the Andes in Patagonia, the peri-Andean Central West, and the Northwest, where there has been intensive archaeological research for an extended period and there are fewer systematic factors which are likely to bias archaeological visibility, the absence of archaeological evidence of early occupation may indicate delayed colonization of these more marginal environments. The conclusion discusses the implications of ^{14}C dates associated with Fishtail Projectile Points for the western hemisphere pre-Clovis debate, and the implications of terminal Pleistocene/early Holocene dated remains of extinct mammals for the megafaunal overkill hypothesis.

1. Introduction

From the 1980s onwards, Argentinian archaeology has generated a large body of new data which has fuelled debate on the early peopling of the Americas (see discussions in Goebel et al., 2008; Salemme and Miotti, 2008; Borrero, 2009; Steele and Politis, 2009). There have been not only numerous new archaeological sites reported and discussed, but also more sophisticated analyses of site formation processes, which included geoarchaeology, microstratigraphy and taphonomy. Even though there are still large gaps in knowledge of the early prehistory of Argentina, compilation and analysis of a database of existing early sites will allow greater understanding of the evidence base both for initial continental dispersal patterns, and for the subsequent evolution of a more regionalized spatial population structure.

In this paper, initial results of an analysis of a database of ^{14}C-dated early Argentinian archaeological sites are presented. This includes all radiocarbon evidence dating between 13,000 and 7000 ^{14}C BP, subject to certain inclusion criteria. The main goals of the initial analysis are: (a) to explore the spatial distribution of early sites, and (b) to characterize possible evidence of variation in settlement density in space and through time; to do this, the main taphonomic variables will also be considered.

2. Environmental settings

Argentina is the larger part of the Southern Cone of South America, extending latitudinally between 22° and 55° S (ca. 2.8 million km^2). It is limited by the Atlantic Ocean to the central-east and southeast, Bolivia to the northwest, Paraguay to the north, Brazil and Uruguay to the northeast, and by the Andean mountain range to the west. The Andean mountain range runs the full length of the western side of South America forming the 'backbone' of the Southern Cone. To the west, there is a strip of land between the Pacific coast and the mountains (the present territory of Chile). East of the Andes there are extensive plains and plateaus that reach the Atlantic coast, forming a mosaic of environments. These are interrupted by just a few higher-altitude range systems

* Corresponding author.
E-mail addresses: lprates@fcnym.unlp.edu.ar (L. Prates), gpolitis@fcnym.unlp.edu.ar (G. Politis), j.steele@ucl.ac.uk (J. Steele).

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(e.g. Sierras Centrales, Tandilia and Ventania). As a first approximation this environmental mosaic can be subdivided into six main regions, whose areas were calculated using ArcMAP 10 software; from the north to the south: 1) Northwest, 2) Northeast, 3) Chaco, 4) Central West, 5) Pampas, and 6) Patagonia including Tierra del Fuego (see Fig. 1). The Northwest region (NW) has an area of approximately 387,000 km^2 and includes several subregions: the Puna or altiplano (a high altitude dry plateau located between 3400 and 4500 masl), the valleys and quebradas (located below 3000 masl) and the subtropical forest (a narrow band which extends along the foothills of the eastern mountain ranges). From an archaeological perspective, the NW is the southern border of the “Andean cultures”. The Northeast region (NE), which partially corresponds to Argentinian “Mesopotamia” or “Littoral”, is a large subtropical humid/warm area (ca. 196,000 km^2) bounded by the gallery tropical forest of the Uruguay and Parana rivers. Between NW and NE is the Chaco, the largest forested region in Argentina. Chaco is a flat and dry/warm environment, of about 349,000 km^2, much covered by hardwood forest. South of the Chaco is the Central West region (341,000 km^2), which includes both the mid-altitude mountain ranges of Córdoba and San Luis (Sierras Centrales), and the dry and mountainous area (the pre-cordillera and the eastern slope of the Andes) of western Argentina (Mendoza and San Juan provinces); the latter can be divided (from east to west, and from lowland to highland) into Eastern Plains of Andes, Intermontane Valleys, and High Andes (Neme and Gil, 2008). The Pampas region is a grassland plain of about 666,000 km^2, with a flat to gently undulating landscape, having a deep mantle of loess, located in eastern Argentina between 31° and 39° South, and bordered by the Paraná-Plata rivers to the northeast, the Atlantic Ocean to the east,

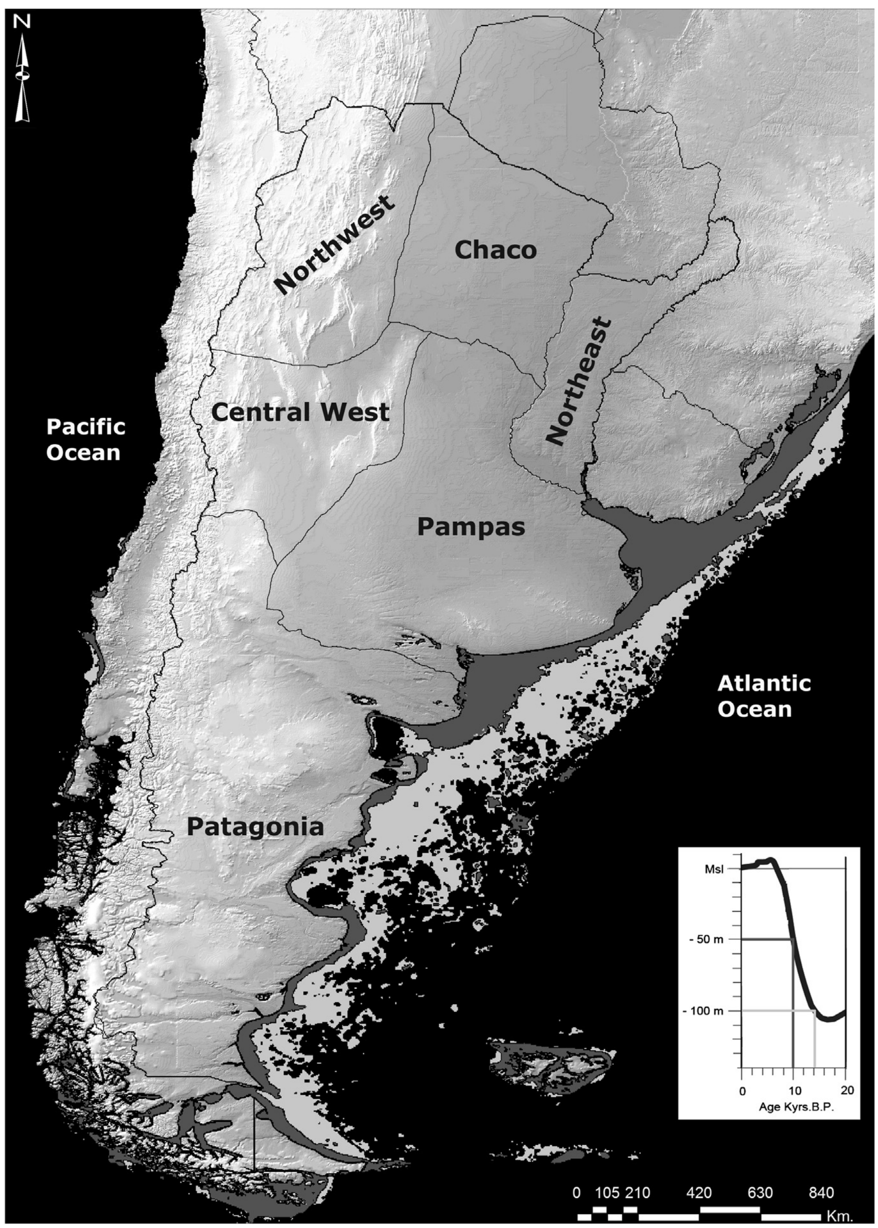

Fig. 1. Archaeological regions in Argentina as used in this paper. Inset shows the relative sea level curve from Violante and Parker (2004), and greyscale shading indicates the modern 50 m and 100 m depth contours. The timescale for the rsl curve is given in uncalibrated ^{14}C BP.

and the Sierras Centrales and foothills of the Andes mountain range to the west. Pampas can be broadly divided into two main subregion: Dry Pampas (to the West) and Humid Pampas (to the East), this latter include both the Interserrana area and the Tandilia and Ventania range systems. Finally, the southernmost region of the Southern Cone is Patagonia, located between 39° and 55° S. in latitude (ca. 826,000 km^2). Most of this region is a dry/cold treeless plateau deeply cut by several major rivers with courses flowing in a mainly west to east direction. Argentinian Patagonia is limited by the Atlantic Ocean to the east and by the high peaks of the Andes to the west. This large region can broadly divide into three subregions, Northern, Central and Southern; the latter includes Tierra del Fuego, which is separated from continental Patagonia by the Strait of Magallanes.

In this paper, there is insufficient space to examine paleoenvironmental reconstructions and their relevance in validating these regional divisions, although it would be useful to do this in the future. However, the late Pleistocene and early Holocene survey period saw the progressive inundation of massive areas of exposed continental shelf to the east of the modern Argentinian Atlantic coastline (Fig. 1; cf. Violante and Parker, 2004; Ponce et al., 2011). The parts of this shelf which were still exposed in the earlier millennia of the survey period would have provided an extensive area of colonizable habitat, while the eastward extension of the late glacial Atlantic coastline would probably have led to increased continentality in the climate of surveyable land areas now much closer to the present-day shoreline.

Fig. 2. Late Pleistocene–early Holocene archaeological sites in Argentina.

3. Materials and methods

The ^{14}C dates considered in this paper were obtained through exhaustive review of published information, supplemented by a few unpublished dates provided by individual researchers. The database is organized with single radiocarbon dates as the basic recording unit. Nevertheless, for assessing general demographic trends an attempt was made to standardise for inter-site variation in dating effort by defining 'occupations' as the units of analysis, in many cases by averaging more than one ^{14}C date. This was primarily to mitigate the over-representation of sites/regions where scientists had undertaken unusually intensive dating programs, and where the relative density of dates therefore greatly exceeded the relative density of sites or artefacts; it was, in other words, a heuristic device to reduce the biasing effects of nonuniform research effort or scientific biases (Ballenger and Marbly, 2011) when estimating demographic trends in different sites and regions. For this purpose, occupations were assigned an average value from multiple dates from a single site where those dates were statistically indistinguishable at $\alpha = 0.05$ according to Ward and Wilkins' test (1978).

For each of the radiocarbon dates in the database, the following information was included: summary information on the site (region, latitude and longitude, environmental setting); ^{14}C age; calibrated age; nature of sample; dating method; laboratory code; cultural context (site function, artefact association, kind of faunal remains); and bibliographic references. The aim of this study is not to address each site in detail, but to discuss general trends emerging from initial analysis of the data. Although all published archaeological ^{14}C dates were included in the database, this paper did not consider those with high error bars ($\geq$300 years) and those that had inconsistent, weak or non-existent evidence for an association with contemporaneous human occupation.

Commonly-stated requirements for securely diagnosing and dating past human activity at an archaeological location are that there should be undeniable traces of humans (artefacts or skeletons) in undisturbed geological deposits, with indisputable dates (Haynes, 1969; Dincauze, 1984). A more detailed recent specification stipulates the following standards of validity for early Palaeoindian sites: there should be a consistent series of accurate and statistically precise radiometric dates (error bars <300 years), based on taxonomically-identified single objects of carefully cleaned cultural carbon (which will be considered especially reliable if fruit/seed remains or purified amino acid fraction of bones/teeth of prey animals), found in primary stratigraphic association with artefacts, and with the results documented by peer-review publication (Roosevelt et al., 2002).

Averaging of ^{14}C ages, and any subsequent calibration, was done using Calib 6.0.1 (Stuiver and Reimer, 1993) and the INTCAL09 calibration curve (Reimer et al., 2009). There is significant uncertainty in estimation of the calibration curve for ^{14}C dates in the earlier part of the survey period. INTCAL04 (Reimer et al., 2004) and INTCAL09 (Reimer et al., 2009) use the same tree-ring series for the period 0–12,550 cal BP, but diverge for the immediately preceding period. INTCAL09 – which also nearly doubles the length of the calibration curve to 50,000 cal BP – uses only marine data for periods before 12,550 cal BP (Reimer et al., 2009), The Huon Pine (HP-40) YD tree-ring sequence anchors the previously floating Late Glacial Pine (LGP) ^{14}C sequence (Hua et al., 2009), and supports the reduction in calendar age of radiocarbon determinations (12,900–12,550 cal BP) found using INTCAL09, when compared with results found using INTCAL04. However, a plot of the anchored LGP tree-ring C14 sequence (Hua et al., 2009: 2986) also suggests that a Pacific coral-based calibration may overestimate both that reduction in age at the younger end of the range (12,700–12,550 cal BP), and the associated uncertainty due to trends in atmospheric ^{14}C concentration. Future revisions of the calibration curve incorporating the anchored LGP tree-ring ^{14}C series therefore seem likely to change the picture again. This problem particularly affects fine-grained analysis of colonization events in the crucial period around the onset of the Younger Dryas in Noth Americas and the end of the Antarctic Cold reversal in Southern South America. The SHCal southern hemisphere calibration curve (McCormac et al., 2004) is meanwhile available for the period 0–11,000 cal BP. The mean offset from recent dendrochronological control data is 56 ± 24 years, SHCal-calibrated dates being that much younger than those calibrated using a northern hemisphere curve; but McCormac et al. note that this offset should not be generalized to pre-Holocene situations because of the unknown effects of large-scale carbon reservoir changes. Future analyses will explore the selective use of this curve for the younger dates. However, this paper conservatively analyses the database by grouping events into ^{14}C millennium intervals, while also indicating their approximate calendar age ranges based on INTCAL09.

4. Results

The analyzed database currently contains 274 radiocarbon dates falling within the range 13,000–7000 ^{14}C BP (all individual dates in this paper are expressed as radiocarbon ages, pending further analysis of calibration effects in the earlier part of the survey period) from 72 archaeological sites (Fig. 2), with an average of just over 3.8 dates per site. The sites are mostly located in caves and rock shelters (77.8%; $n = 56$: caves $n = 33$ and rock shelters $n = 23$); open-air sites are scarce (22.2%; $n = 16$) and only one of the latter is a shell midden (Arroyo Verde site, Gómez Otero, 2007). On a regional basis, the sites are located in Pampas (36.1%; $n = 26$), Patagonia (33.3%; $n = 24$), Northwest (16.7%; $n = 12$) and Central West (13.9%; $n = 10$). There are no sites included from the regions of Chaco and the Northeast. Most radiocarbon dates were obtained from sites in Patagonia (31.8%; $n = 87$ dates), Pampas (29,6%; $n = 81$ dates), Central West (19.3%; $n = 53$ dates) and Northwest (19.3%; $n = 53$ dates). Considering only occupation events, the currently-estimated minimum number in the database is 171. These occupations occur at sites in Pampas (32.1%; $n = 55$ events), Patagonia (31.6%; $n = 54$ events), Northwest (21.1%; $n = 36$ events) and Central West (15.2%; $n = 26$ events) (see Supplementary material). This paper will comment in more detail on settlement phasing and on possible trends and fluctuations in event frequency, after calibration of the dates in this database. Initially, however, comment will focus on patterns of occurrence in successive 1000 ^{14}C year BP periods in the interval 13,000–7000 ^{14}C BP.

4.1. 13,000–12,000 ^{14}C BP (ca. 15,500–13,900 cal BP)

From this period (Table 1), three sites are discussed in the literature: Los Toldos and Piedra Museo (both in the Patagonian region) and Arroyo Seco 2 (Pampas region). In the case of Los Toldos Cueva 3, the relevant date is a conventional measurement on a composite bulk charcoal sample of 12,650 ± 650 ^{14}C BP from Level 11, associated with a unifacial lithic industry (Cardich et al., 1973). However, the laboratory setup and procedures are poorly documented, the statistical uncertainty on the date is very large, and this date has not been replicated on other samples or using more recent techniques. Until new dates on associated samples are obtained, this date is now usually discounted in discussions of the early settlement chronology of the Southern Cone (Borrero, 1996; Dillehay, 2009). It is therefore not included in the present database.

Table 1
Dates for the 13–12th ^{14}C millennium BP, including those excluded from the analysis but mentioned in the text.

Site	Lat (South)	Long (West)	^{14}C years	Sigma	Lab. code	Reference
Piedra Museo AEP-1	−47.895	−67.8677	12,890	90	AA-20125	Miotti et al., 1999
Los Toldos	−47.3666	−68.9666	12,600	500		Cardich et al., 1973
Arroyo Seco 2	−38.3605	−60.2441	12,240	110	OXA-4591	Steele and Politis, 2009
Arroyo Seco 2	−38.3605	−60.2441	12,200	170	CAMS-58182	Steele and Politis, 2009
Arroyo Seco 2	−38.3605	−60.2441	12,170	55	OxA-15871	Steele and Politis, 2009
Arroyo Seco 2	−38.3605	−60.2441	12,155	70	OxA-10387	Steele and Politis, 2009
Arroyo Seco 2	−38.3605	−60.2441	12,070	140	OxA-9243	Steele and Politis, 2009

In the site of Piedra Museo, located quite close to Los Toldos and with a comparable lithic industry in the earliest layer, there are nine radiocarbon dates from Unit 6, the lowest archaeological layer (Miotti et al., 2003; Steele and Politis, 2009). These give the layer a date range of 12,890–10,400 ^{14}C BP. However, the oldest charcoal date of 12,890 ± 90 ^{14}C BP (AA-20125, Miotti et al., 2003) is an outlier which has not been replicated on the other samples, all of which date to 11,000 ^{14}C BP or later. The presence of humans at the site in this millennium must also therefore be considered uncertain, pending further confirmatory evidence (see discussion in Steele and Politis, 2009).

At Arroyo Seco 2, an open-air site located in the Interserrana area of the Pampas region, radiocarbon dates on the megafaunal assemblage indicate at least three clusters of ages-at-death (Steele and Politis, 2009), suggesting that the giant sloth *Megatherium* had died c. 12,100 ^{14}C BP (average of four dates), the *Toxodon* had died c. 11,750 ^{14}C BP, and that two or more horses (*Equus* and *Hippidion*) had died c. 11,200 ^{14}C BP. Of these, the oldest event falls within the millennium under consideration. The sampled bone has helical fracture patterns which are interpreted by the site's taphonomists as cultural modifications probably associated with marrow extraction (Gutiérrez and Johnson, in press). Corroborating evidence for a human association with the entire megafaunal assemblage includes the association of a unifacial lithic assemblage in the same stratigraphic unit; the selective representation in this assemblage of appendicular skeletal elements; and the open setting of the site on a low loess dune, which is viewed by the investigators as inconsistent with a natural accumulation of such a diversity of megamammals. These features of the site are detailed in the forthcoming site monograph (Politis et al., in press).

The issue of the date of the earliest cultural episode at Arroyo Seco 2 requires a decision on how many independent cultural accumulation events took place involving transport to the site and processing of skeletal elements. The investigators consider that the *Megatherium*, *Hippidion* and *Equus* remains provide evidence of human activity, in each case timed at or shortly after the death of the animals (Politis et al., in press). The forthcoming monograph will set out in detail the basis for these arguments (Politis et al., in press). If it is accepted that the assemblage represents two separate cultural accumulation episodes at approximately 900 ^{14}C year intervals (the *Toxodon* seems to be in the site for natural causes), then the *Megatherium* age-at-death, which falls within this initial millennium, represents evidence of human occupation at this early date.

4.2. 12,000–11,000 ^{14}C BP (ca. 13,900–12,800 cal BP)

In this ^{14}C millennium (Table 2) there are dates from Arroyo Seco 2 (Interserrana area, Pampas region; the site's megafaunal assemblage includes *Toxodon* c. 11,750 ^{14}C BP, and *Equus* and *Hippidion* c. 11,200 ^{14}C BP, see preceding section); Cerro La China 2 (Tandilia mountain range, Pampas region; one date of 11,150 ± 135 ^{14}C BP; Flegenheimer, 1987); Cerro Tres Tetas 1 (Deseado basin, Patagonia; a site where a set of hearth charcoal dates average to 10,886 ± 48 ^{14}C BP and 11,087 ± 45 ^{14}C BP, Paunero, 2003a; Steele and Politis, 2009); Casa del Minero 1 (Deseado basin, Patagonia; two dates averaging to 10,983 ± 39 ^{14}C BP, Paunero, 2003b); and Piedra Museo, AEP-1 (Deseado basin, Patagonia; one date of 11,000 ± 65 ^{14}C BP; Miotti et al., 2003). In the case of Cerro Tres Tetas 1, a conventional ^{14}C age (11,560 ± 140 BP, LP-525) from the database was excluded. This was rejected by Steele and Politis (2009) after re-dating the same charcoal sample (10,915 ± 65 BP, OxA-9244; 10,853 ± 70 BP, AA39366) and obtaining new dates from the same hearth (11,015 ± 66 BP, AA39368; 11,145 ± 60 BP, OxA-10745).

Table 2
Dates for the 12–11th ^{14}C millennium BP, including those excluded from the analysis but mentioned in the text.

Site	Lat (South)	Long (West)	^{14}C years	Sigma	Lab. code	Reference
El Alto 3	−31.3988	−64.7388	11,010	80	LP-1506	Rivero and Roldán, 2005
Cerro La China II	−37.95	−58.6166	11,150	135	AA-8955	Flegenheimer, 1987
Arroyo Seco 2	−38.3605	−60.24416	11,750	70	CAMS-16389	Steele and Politis, 2009
Arroyo Seco 2	−38.3605	−60.24416	11,730	70	OxA-9242	Steele and Politis, 2009
Arroyo Seco 2	−38.3605	−60.24416	11,320	110	AA-39365	Steele and Politis, 2009
Arroyo Seco 2	−38.3605	−60.24416	11,250	105	AA-7964	Steele and Politis, 2009
Arroyo Seco 2	−38.3605	−60.24416	11,000	100	OXA-4590	Steele and Politis, 2009
Piedra Museo, AEP-1	−47.895	−67.8677	11,000	65	AA-27950	Miotti et al., 2003
Cerro Tres Tetas, C1	−48.1661	−68.9333	11,560	140	LP-525	Paunero, 2003a
Cerro Tres Tetas, C1	−48.1661	−68.9333	11,145	60	OxA-10745	Steele and Politis, 2009
Cerro Tres Tetas, C1	−48.1661	−68.9333	11,100	150	AA-22233	Paunero, 2003a
Cerro Tres Tetas, C1	−48.1661	−68.9333	11,015	66	AA-39368	Paunero, 2003a

The majority of these dates cluster around c. 11,000 ^{14}C BP and by this time there is therefore consistent evidence of an established human presence in the Patagonian and Pampas regions. Two sites from the Central West region are also included tentatively here: Agua de la Cueva, in the pre-cordillera of Mendoza province (dated to 10,950 ± 190 ^{14}C BP) and El Alto 3, in Pampa de Achala, Córdoba Mountains (dated in 11,010 ± 80 ^{14}C BP). However both dates should be still taken with caution until new samples from the same levels are dated. Although the archaeological contexts in the two sites show good integrity and resolution (see García, 2003; Rivero and Roldán, 2005) both dates are at the older extreme of the date series obtained so far. In the case of El Alto 3, a second sample from the same stratigraphic unit (unid 4) gave an age ca. 9790 ± 80 (LP-1420) (Rivero and Roldán, 2005) which necessitates considering the older date with caution.

For this period, possible evidence of extinct mammal exploitation is recorded at several sites. In addition to the species found at the Arroyo Seco 2 site in the Pampas, *Hemiauchenia* cf. *paradoxa* (with human modification) and *Lama gracilis* remains (without direct evidence of human agency but in close association with a hearth and other anthropogenic materials e.g. lithics and guanaco bones) were found at the Casa del Minero 1 site and there were remains of *Hippidion saldiasi* (with cut marks), *Lama gracilis (?)*, and *Mylodon* sp. at the Piedra Museo site, both in Patagonia. Probable remains of extinct camelid (attributed to *Lama gracilis*) were also found at Agua de la Cueva site (layer 2b), and if correctly assigned, this would be the first record of the species in the region (García, 2010). However Gil et al. (2011:600) recommend caution because these remains have too few diagnostic features to make species-level identification, while a recent genetic analysis (Weinstock et al., 2009) found no differences between *Lama (vicugna) gracilis* and *Vicugna vicugna*. It is not clear that megafaunal species were the main food resource at any of these sites. On the contrary, extant fauna, particularly *Lama guanicoe*, seem to have been a mainstay of the early hunter–gatherer economy (e.g. at Piedra Museo, Cerro Tres Tetas, and Agua de la Cueva).

The lithic technology from most of the sites during this ^{14}C millennium is characterized by a lithic industry mostly composed of cores, debitage, and informal tools. The latter include: unifacial, marginally retouched artefacts in Arroyo Seco 2 (Leipus, in press); knives, side scrapers and unretouched large flakes in Piedra Museo, AEP-1 (Miotti and Cattáneo, 2003); a side scraper and a knife in Casa del Minero 1 (Paunero, 2003b); and side scrapers, a hammer stone, a chopper, and retouched flakes in Cerro Tres Tetas 1 (Paunero, 2003a). In most cases (e.g. Arroyo Seco 2, Piedra Museo, Cerro La China 2, Cueva Casa del Minero 1, El Alto 3, and Agua de la Cueva) some of the debitage was identified as the product of bifacial technology. No projectile points of any type have been found that date securely to this period. Although Cerro La China 2 could be considered an exception (the date of 11,150 ± 135 ^{14}C BP comes from a layer with a fishtail projectile point), another date from the same component gave a younger age (10,560 ± 75 ^{14}C BP). The correct date association for the projectile point remains to be resolved.

4.3. 11,000–10,000 ^{14}C BP (ca. 12,800–11,400 cal BP)

In addition to those mentioned above, the database contains dates for 39 occupation events (64 dates) coming from 25 sites during this ^{14}C millennium (Supplementary material; Table 3). These occupations show a wider spatial dispersion than those of the preceding period, and include a small number of sites outside the Pampas and extra-Andean Patagonia: Gruta del Indio and Agua de la Cueva (in the eastern plains and intermountain valleys respectively of Mendoza province, Central West region); El Trébol (Andes of Northern Patagonia); Cerro Casa de Piedra 7 (foothills of the Andes, Southern Patagonia); and León Huasi, Cueva de Yavi, Inca Cueva 4, Peñas de las Trampas 1.1, and Pintoscayoc 1 (Puna, Northwest region). There are no known archaeological sites in the Northeast and Chaco regions, nor in these subregions: valleys, quebradas and subtropical forest in the Northwest region; Dry Pampas (Pampas); High Andes, San Luis mountain range, and Córdoba range systems (Central West); central Patagonia. Precise and accurate dating of occupations remains dependent on a close reading of site taphonomy: for example, in this period there are two dates from the Gruta del Indio site (in the Central West region) which average to 10,903 ± 75 ^{14}C BP (see García, 2003), but which were not used in the analysis because they were obtained from sloth dung and are not clearly associated with humans. Of the two dates on charcoal more closely related to human activity from the same site, one is 400 ^{14}C yrs younger, and the other (10,930 ± 540, A-1373) was excluded because the error bar is greater than 300 years (see García, 2003; Gil and Neme, 2010).

Table 3
Dates for the 11–10th ^{14}C millennium BP, including those excluded from the analysis but mentioned in the text.

Site	Lat (South)	Long (West)	^{14}C years	Sigma	Lab. code	Reference
Peñas de las Trampas 1.1	−26.0175	−67.35	10,190	190	UGA-01975	Martínez et al., 2010
Peñas de las Trampas 1.1	−26.0175	−67.35	10,030	100	LP-1788	Martínez et al., 2010
Inca Cueva 4	−23	−65.45	10,620	140	LP-137	Aschero and Podestá, 1986
León Huasi			10,550	300	GAK-13402	Fernández Distel, 1989
La Cueva de Yavi	−22.1166	−65.4666	10,450	55	CSIC-1101	Kulemeyer and Laguna, 1996
Pintoscayoc 1	−22.9444	−65.4182	10,720	150	LP-503	Hernández Llosas, 2000
Pintoscayoc 1	−22.9444	−65.4182	10,340	70	Beta-79849	Hernández Llosas, 2000
Gruta del Indio	−34.75	−68.3666	10,930	540	A-1373	Gil and Neme, 2010
Gruta del Indio	−34.75	−68.3666	10,610	210	A-1351	Gil, 2005
Gruta del Indio	−34.75	−68.3666	10,530	140	A-1638	Gil, 2005
Gruta del Indio	−34.75	−68.3666	10,440	225	A-9487	Gil, 2005
Gruta del Indio	−34.75	−68.3666	10,285	240	A-9494	Gil, 2005
Gruta del Indio	−34.75	−68.3666	10,200	300	A-1636	Gil, 2005
Gruta del Indio	−34.75	−68.3666	10,195	80	A-9497	Gil, 2005
Gruta del Indio	−34.75	−68.3666	10,170	70	A-9498	Gil, 2005
Gruta del Indio	−34.75	−68.3666	10,135	95	A-9486	Gil, 2005
Agua de la Cueva	−32.6169	−69.1802	10,950	90	Beta-61409	García et al., 1999
Agua de la Cueva	−32.6169	−69.1802	10,350	220	Beta-26250	García et al., 1999
Agua de la Cueva	−32.6169	−69.1802	10,240	60	Beta-61408	García et al., 1999
Cueva Tixi			10,375	90	AA-12130	Mazzanti and Quintana, 2001
Cueva Tixi			10,045	95	AA-12131	Mazzanti and Quintana, 2001
Abrigo Los Pinos			10,465	65	AA-24045	Politis et al., 2004
Abrigo Los Pinos			10,415	70	AA-24046	Martínez et al., 2011
Cerro La China I	−37.95	−58.6166	10,804	75	AA-8953	Flegenheimer and Zárate, 1997
Cerro La China I	−37.95	−58.6166	10,790	120	AA-1327	Flegenheimer, 1987

(continued on next page)

Table 3 (*continued*)

Site	Lat (South)	Long (West)	^{14}C years	Sigma	Lab. code	Reference
Cerro La China I	−37.95	−58.6166	10,745	75	AA-8952	Flegenheimer and Zárate, 1997
Cerro La China I	−37.95	−58.6166	10,730	150	I-12741	Flegenheimer, 1987
Cerro La China I	−37.95	−58.6166	10,525	75	AA-8954	Politis et al., 2004
Cerro La China II	−37.95	−58.6166	10,560	75	AA-8956	Flegenheimer, 1987
Cerro La China III	−37.95	−58.6166	10,610	180	AA-1328	Flegenheimer, 1987
Cerro El Sombrero, A1	−37.8166	−58.5666	10,725	90	AA-4765	Flegenheimer and Zárate, 1997
Cerro El Sombrero, A 1	−37.8166	−58.5666	10,675	110	AA-4767	Flegenheimer and Zárate, 1997
Cerro El Sombrero, A 1	−37.8166	−58.5666	10,480	70	AA-5220	Flegenheimer and Zárate, 1997
Cerro El Sombrero, A 1	−37.8166	−58.5666	10,270	85	AA-4766	Flegenheimer and Zárate, 1997
Paso Otero 5	−38.2022	−59.1327	10,440	100	AA-39363	Steele and Politis, 2009
Paso Otero 5	−38.2022	−59.1327	10,190	120	AA-19291	Politis et al., 2004
Arroyo Seco 2	−38.3605	−60.2441	10,500	90	AA-9049	Politis and Beukens, 1991
Arroyo de Frías	−34.65	−59.4307	10,300	60	CAMS-16598	Politis and Bonomo, 2011
Cueva Burucuyá			10,000	120	LP-863	Mazzanti, 2003
Amalia Sitio 2			10,425	75	AA-35499	Politis et al., 2004
Cueva Zoro	−37.8166	−58.6333	10,153	61	AA-82707	Mazzia, 2011
Cueva Zoro	−37.8166	−58.6333	10,094	62	AA-82706	Mazzia, 2011
Piedra Museo, AEP-1	−47.895	−67.8677	10,925	65	OxA-8528	Miotti et al., 2003
Piedra Museo, AEP-1	−47.895	−67.8677	10,675	55	OxA-15870	Steele and Politis, 2009
Piedra Museo, AEP-1	−47.895	−67.8677	10,470	65	GRA9837	Miotti et al., 2003
Piedra Museo, AEP-1	−47.895	−67.8677	10,470	60	OxA-9249	Miotti et al., 2003
Piedra Museo, AEP-1	−47.895	−67.8677	10,400	80	AA-8428	Miotti et al., 2003
Piedra Museo, AEP-1	−47.895	−67.8677	10,400	70	AA-39367	Steele and Politis, 2009
Piedra Museo, AEP-1	−47.895	−67.8677	10,390	70	OxA-8527	Steele and Politis, 2009
Piedra Museo, AEP-1	−47.895	−67.8677	10,100	110	OxA-9507	Steele and Politis, 2009
Cerro Casa de Piedra 7	−47.9552	−72.0947	10,690	72	UGA-873	Aschero et al., 2007
Cerro Tres Tetas, C1	−48.1661	−68.9333	10,915	65	OxA-9244	Steele and Politis, 2009
Cerro Tres Tetas, C1	−48.1661	−68.9333	10,853	70	AA-39366	Steele and Politis, 2009
Cerro Tres Tetas, C1	−48.1661	−68.9333	10,850	150	LP-781	Miotti and Salemme, 2003
Cerro Tres Tetas, C1	−48.1661	−68.9333	10,260	110	LP-800	Miotti and Salemme, 2003
Casa del Minero	−48.5594	−68.8552	10,999	55	AA-37207	Paunero, 2003b
Casa del Minero	−48.5594	−68.8552	10,967	55	AA-37208	Paunero, 2003b
Casa del Minero	−48.5594	−68.8552	10,250	110	AA-45705	Paunero, 2003b
Cueva Túnel	−48.4575	−68.8725	10,510	100	AA-82496	Paunero et al., 2010
Cueva Túnel	−48.4575	−68.8725	10,420	180	LP-1965	Paunero et al., 2010
Cueva Túnel	−48.4575	−68.8725	10,408	59	AA-71147	Paunero et al., 2010
Cueva Túnel	−48.4575	−68.8725	10,400	100	AA-71148	Paunero et al., 2010
La Gruta, Laguna 2, C1	−48.8261	−69.3961	10,845	61	AA-84224	Franco et al., 2010
La Gruta, Laguna 2, C1	−48.8261	−69.3961	10,656	54	AA-76792	Franco et al., 2010
La Gruta, Laguna 2, C1	−48.8261	−69.3961	10,477	56	AA-84225	Franco et al., 2010
El Trébol	−41.0733	−71.4866	10,570	130	AA-65707	Adam Hajduk pers. com.

Although it is not always possible to use available dates and stratigraphic records from a site to distinguish assemblages from succeeding ^{14}C millennia, faunal exploitation patterns in the 11–10th ^{14}C millennium BP seem to be analogous to those from the previous period. Extinct mammals of various species have been identified in several archaeological sites, but in only a few cases can human agency in depositing them at the site be demonstrated: Cueva Casa del Minero 1 (*Hemiauchenia* cf. *paradoxa*) (Paunero, 2003b); Paso Otero 5 (*Hemiauchenia* sp.) (Martínez, 2001); El Trébol (Mylodontinae) (Hajduk et al., 2004, 2006); and Piedra Museo (*Hippidion saldiasi*) (Miotti et al., 2003). Close spatial association between bones of extinct mammal species and archaeological artefacts and features (lithics, hearths, and/or other faunal remains) were also reported at Cueva Tixi (*Eutatus seguini*), Cerro La China 1 (*Eutatus seguini*), Paso Otero 5 (*Megatherium americanum*, *Glossotherium* sp., *Glyptodon* sp., *Toxodon* sp. and *Equus neogeus*; probably used as fuel), Cueva Casa del Minero 1 (*Lama gracilis*), Cueva Túnel (*Hippidion saldiasi*, Hemiauchenia sp., *Lama* (Vicugna) *gracilis*, Panthera sp.), and Piedra Museo (*Lama gracilis* and *Mylodon*). At the site of Gruta del Indio human exploitation of *Mylodon* and *Megatherium* (Lagiglia, 2002) has been suggested, but this causal association needs to be tested by a detailed taphonomic analysis and publication of the faunal remains (Long et al., 1998; García, 2003). *Dusicyon avus* (a mid-sized carnivore) is another extinct species whose presence on a site of this period is usually associated with early human occupations (e.g. Cueva Tixi, El Trébol; see discussion in Borrero, 2009; Prevosti et al., 2011). No evidence of megafauna has been reported from the Northwestern region where rodents (*Lagidium* sp.), camelids and cervids seem to have played an important role in hunter–gatherer subsistence (see Aschero, 2000).

Perhaps the most noteworthy technological change during this millennium is the appearance of fishtail projectile points (FTPP) at several, spatially widely dispersed archaeological sites. FTPPs with unambiguous dates appear in Argentina during this ^{14}C millennium. Among these FTPP sites are: Abrigo Los Pinos (Pampas, 10,465 ± 65 and 10,415 ± 65 ^{14}C BP, Mazzanti, 2003), Cerro La China 1 (Pampas, 10,777 ± 49 ^{14}C BP, average of three dates), Cerro La China 2 (Pampas, possibly dated by two samples at 10,610 ± 180 and 10,560 ± 75 ^{14}C BP, see above; Flegenheimer et al., 2010); Cerro El Sombrero Abrigo 1 (Pampas, dated by four samples which are too different to be averaged: 10,725 ± 90 ^{14}C BP, 10,675 ± 110 ^{14}C BP, 10,480 ± 70 ^{14}C BP, and 10,270 ± 85 ^{14}C BP, Flegenheimer, 2003; a fifth sample gave a more recent age (8060 ± 140, AA-5221) but was discounted by the author), Paso Otero 5 (Pampas, possibly dated by a sample of 10,440 ± 100 ^{14}C BP, Martínez and Gutiérrez, 2011), La Amalia Sitio 2 (Pampas, 10,425 ± 75 ^{14}C BP, Mazzanti, 2003) and Piedra Museo (Patagonia, ca. 10,400 ± 70 ^{14}C BP, Miotti et al., 2003). This suite of dated sites with fishtail points is consistent with chronological indicators from Chilean sites with this type of projectile point (e.g. Fells Cave, Cueva del Medio, Valiente, Tagua Tagua 2 and Salar de Punta Negra, see Méndez, in this issue).

In order to map more completely the spread of FTPP technology in Argentina, it is useful also to summarize finds locations with no associated ^{14}C date. Most of these are surface finds either in isolation or in assemblages which were not recovered in their original archaeological context. Isolated FTPPs have been reported at the following locations: Antofalla (Puna de Atacama, Northwest) (Grosjean et al., 2005); Valle del Bolsón (Catamarca, Northwest) (Grosjean et al., 2005); Cobres (Puna de Salta, Northwest) (Patané Aráoz, in press); La Crucecita and Ranquil Norte (Mendoza, Central West) (Schobinger, 1971; Lagiglia, 2002, in García, 2003:156); Los Toldos, Cave 2 (Southern Patagonia) (Menghín, 1952:37; Bird, 1970:205); Gobernador Moyano (Southern Patagonia) (Bate, 1982, in Politis, 1991:290); El Ceibo, near Cave 7 (Southern Patagonia) (Cardich, 1979:172); Sauce Chico (Pampas) (Silveira, 1978, in Flegenheimer, 1980:169); Arroyo Bellamar (Bonomo, 2005:139) (Pampas coast); Arroyo La Ballenera, Arroyo La Carolina, Miramar, Los Ángeles y Monte Hermoso (Flehenheimer and Bayón, 1996) (Pampas coast), Luján (Pampas) (Zeballos and Reid, 1876:Fig. I, pp.314); Lobos (Pampas) (Eugenio, 1983:23); San Cayetano (Pampas) (Politis, 1991:290); Tapera Moreira (Dry Pampas) (Berón, 2004); Guatraché (Dry Pampas) (Berón and Carrera Aizpitarte, 2012) La Marcelina (Limay basin, extra-Andean Northern Patagonia) (Crivelli Montero, 2010:279); Neuquén (Northern Patagonia) (Schobinger, 1973); Córdoba (Central West) (Schobinger, 1973); Estancia La Suiza (mountain range of Córdoba, Central West) (Laguens et al., 2007); Santa Lucía (Monte Caseros, Corrientes province, Northeast) (Mujica, 1995:204–205) and Santa Eloisa (Entre Ríos, Northeast) (Capeletti, 2011). This distribution of undated finds suggests that FTPP technology was widespread through most Argentinian regions (for a wider geographical perspective, see also Castiñeira et al., 2011).

In addition to isolated finds of FTPPs, at some noteworthy sites, such as Cerro El Sombrero Cima, and Amigo Oeste, more than a hundred FTPPs were found in relatively restricted areas. Cerro El Sombrero Cima is located in the Tandilia Range system (Pampas) (Flegenheimer, 2003), and Cerro Amigo Oeste in the Somuncura Plateau (Northern Patagonia) (Miotti et al., 2010). It is important to highlight that both sites, probably the only ones of their kind yet known in South America, are on the tops of hills which are located in relatively flat areas. This provides a favourable topographic location with excellent visual control over the surrounding landscape.

4.4. 10,000–9000 ^{14}C BP (ca. 11,400–10,200 cal BP)

The database contains records for 41 occupation events from 30 sites (defined on the basis of 66 dates) during this ^{14}C millennium (Supplementary material; Table 4), including 6 occupations from 3 sites in the Central West region, 11 from 7 sites in the Northwest region (all in the Puna desert), 10 from 9 sites in the Pampas (all in the humid Pampas), and 14 from 11 sites in Patagonia. This highlights the tendency already observed in the previous ^{14}C millennium for a greater geographical extent of occupation. Nevertheless, ^{14}C-dated human occupation has not yet been identified from this period in the Northeast, Chaco, Dry Pampas, the valleys, quebradas and the subtropical forest of the North West, or in the San Luis mountain range, intermontane valleys and High Andes of the Central West.

Table 4
Dates for the 10–9th ^{14}C millennium BP.

Site	Lat (South)	Long (West)	^{14}C years	Sigma	Lab. code	Reference
Quebrada Seca 3	−26.0833	−67.4166	9790	50	UGA-9257	Hocsman, 2002
Quebrada Seca 3	−26.0833	−67.4166	9410	120	LP-881	Hocsman, 2002
Quebrada Seca 3	−26.0833	−67.4166	9250	100	LP-895	Hocsman, 2002
Quebrada Seca 3	−26.0833	−67.4166	9050	90	Beta-59930	Aschero et al., 1993–94
Inca Cueva 4	−23	−65.45	9900	200	AC-564	Grosjean et al., 2007
Inca Cueva 4	−23	−65.45	9650	110	LP-102	Grosjean et al., 2007
Inca Cueva 4	−23	−65.45	9230	70	CSIS-498	Grosjean et al., 2007
Huachichocana E3	−23.7558	−65.6386	9620	130	P-2236	Aschero, 1984
La Cueva de Yavi	−22.1166	−65.4666	9790	100	CSIC-1074	Grosjean et al., 2007
La Cueva de Yavi	−22.1166	−65.4666	9760	160	AC-1088	Grosjean et al., 2007
La Cueva de Yavi	−22.1166	−65.4666	9480	220	AC-1093	Grosjean et al., 2007
Pintoscayoc 1	−23.1166	−65.3	9080	50	CAMS-39041	Grosjean et al., 2007
Hornillos 2	−23.2297	−66.4561	9710	270	UGA-13550	Yacobaccio et al., 2008
Hornillos 2	−23.2297	−66.4561	9590	50	UGA-8726	Yacobaccio et al., 2008
Hornillos 2	−23.2297	−66.4561	9150	50	UGA-8723	Yacobaccio et al., 2008
Alero Cuevas	−24.3666	−66.7166	9650	100	LP-1736	López, 2009
Gruta del Indio	−34.75	−68.3666	9990	75	A-9496	Gil, 2005
Gruta del Indio	−34.75	−68.3666	9905	140	A-9489	Gil, 2005
Gruta del Indio	−34.75	−68.3666	9890	75	A-9495	Gil, 2005
Gruta del Indio	−34.75	−68.3666	9825	95	A-9492	Gil, 2005
Gruta del Indio	−34.75	−68.3666	9770	85	A-9491	Gil, 2005
Gruta del Indio	−34.75	−68.3666	9740	280	A-1637	Gil, 2005
Gruta del Indio	−34.75	−68.3666	9700	110	LP-876	Gil, 2005
Gruta del Indio	−34.75	−68.3666	9590	120	LP-860	Gil, 2005
Gruta del Indio	−34.75	−68.3666	9580	105	LP-941	Gil, 2005
Gruta del Indio	−34.75	−68.3666	9560	90	GrN-5772	Gil, 2005
Gruta del Indio	−34.75	−68.3666	9510	90	LP-991	Gil, 2005
Gruta del Indio	−34.75	−68.3666	9160	90	LP-986	Gil, 2005
Agua de la Cueva	−32.6169	−69.1802	9840	90	Beta-26781	García et al., 1999
Agua de la Cueva	−32.6169	−69.1802	9760	160	Beta-61410	García et al., 1999
Agua de la Cueva	−32.6169	−69.1802	9410	90	LP-1548	Lucero et al., 2006
Agua de la Cueva	−32.6169	−69.1802	9250	70	Beta-44696	García et al., 1999
Agua de la Cueva	−32.6169	−69.1802	9210	70	Beta-64539	García et al., 1999
El Alto 3	−31.3988	−64.7388	9790	80	LP-1420	Rivero and Roldán, 2005
Abrigo Los Pinos			9570	120	LP-630	Mazzanti, 2003
Lobería 1. Sitio 1			9787	81	AA-81063	Mazzanti et al., 2010
Paso Otero 5	−38.2022	−59.1327	9560	50	GX-29795	J.G. Martínez et al., 2004
Los Helechos			9640	40	Beta-137747	Flegenheimer and Bayón, 2000
Cueva el Abra			9834	65	AA-38098	Mazzanti, 2003

(continued on next page)

Table 4 (*continued*)

Site	Lat (South)	Long (West)	^{14}C years	Sigma	Lab. code	Reference
Cueva La Brava			9670	120	LP-550	Mazzanti, 1999b
Arroyo de Frías	−34.65	−59.4307	9520	75	OxA-8545	Politis and Bonomo, 2011
El Guanaco 1	−38.6833	−59.65	9250	40	SR-6381	Flegenheimer et al., 2010
El Guanaco 2	−38.6833	−59.65	9140	120	AA-82713	Flegenheimer et al., 2010
El Guanaco 2	−38.6833	−59.65	9048	69	AA-82713	Flegenheimer et al., 2010
Cueva de las Manos	−47.15	−70.75	9320	90	CSIC-138	Gradin et al., 1976
Cueva de las Manos	−47.15	−70.75	9300	90	CSIC-385	Aguerre, 1977
Cueva Grande de Arroyo Feo	−46.9333	−70.5	9410	70	CSIC-514	Alonso et al., 1984–85
Cueva Grande de Arroyo Feo	−46.9333	−70.5	9330	80	CSIC-396	Gradin et al., 1979
Piedra Museo, AEP-1	−47.895	−67.8677	9952	97	AA-39362	Steele and Politis, 2009
Piedra Museo, AEP-1	−47.895	−67.8677	9950	75	OxA-9509	Steele and Politis, 2009
Piedra Museo, AEP-1	−47.895	−67.8677	9710	105	LP859	Miotti et al., 2003
Piedra Museo, AEP-1	−47.895	−67.8677	9350	130	OxA-9508	Steele and Politis, 2009
Piedra Museo, AEP-1	−47.895	−67.8677	9230	105	LP-949	Miotti et al., 2003
Cueva Huenul	−36.95	−69.9	9531	39	AA-85718	Barberena et al., 2010
Cerro Casa de Piedra 7	−47.9552	−72.0947	9730	100	Beta-59955	Civalero and Aschero, 2003
Cerro Casa de Piedra 7	−47.9552	−72.0947	9640	190	UGA 7384	Civalero and Aschero, 2003
Cerro Casa de Piedra 7	−47.9552	−72.0947	9100	150	LP-364	Civalero and Aschero, 2003
Cerro Casa de Piedra 7	−47.9552	−72.0947	9041	64	UGA-869	Aschero et al., 2007
Cueva de La Mesada	−48.0833	−69.8333	9090	40	Beta-135963	Paunero, 2003b
Chorrillo Malo 2	−23.2297	−66.4561	9740	50	GX-25279	Franco and Borrero, 2003
Chorrillo Malo 2	−23.2297	−66.4561	9690	80	CAMS-71152	Franco and Borrero, 2003
Cueva Maripe	−47.8513	−68.9341	9518	64	AA-65175	Miotti et al., 2007
Cueva Cuyin Manzano	−40.6833	−71.25	9920	85	KN-1432	Ceballos, 1982
Cueva Traful 1	−40.7166	−71.1138	9430	230	Ingeis 2676	Crivelli Montero et al., 1993
Cueva Traful 1	−40.7166	−71.1138	9285	105	GX-1711G	Crivelli Montero et al., 1993
Cueva Epullan Grande	−40.3891	−70.1944	9970	100	LP-213	Crivelli Montero et al., 1996

The earliest human skeleton from Argentina comes from this period. This is the skeleton from Arroyo de Frías (Pampas region). It was recovered between 1870 and 1873 by F. Ameghino at Arroyo de Frías, near the town of Mercedes, about 100 km west of Buenos Aires (Politis and Bonomo, 2011). The skeletal remains of at least two individuals were excavated on the left bank of the creek, at a depth of 2.5–3 m. below ground level, by Ameghino, who mentioned this find in several papers (although they contain some contradictory data relating to the discoveries; Hrdlička, 1912; Orquera, 1971). The best preserved and most complete human skeleton was that of an adult female. It was found almost entirely articulated, lying in a flexed position on its right side (Ameghino, 1935). The disposition indicates that this was an intentional, primary burial with only minor evidence of post-depositional disturbance. The second individual, represented by only a few skeletal elements, was a taller and more robust individual, probably an adult male. The female's skull, recovered during the 1870 field season, was donated in 1871 by a collector to the Museo Civico di Storia Naturale of Milan, in Italy, and has been missing since the early 1890s (Hrdlička, 1912; Orquera, 1971). Two different samples from the second individual were dated to 10,300 ± 60 ^{14}C BP (CAMS-16598) and 9520 ± 75 ^{14}C BP (OxA-8545) (Politis and Bonomo, 2011). As a conservative measure, this younger date was the one retained for analysis in the present database.

The diversity of animal taxa found at archaeological sites begins to decrease from this ^{14}C millennium onwards. This process was probably accentuated by the continent-wide decline in numbers and diversity of megafauna (Cione et al., 2003; Borrero, 2009; Barnosky and Lindsey, 2010). In all regions of Argentina for which there are data (Patagonia, Pampas, Central West and North West), camelids (guanaco and vicuña) were the most abundantly represented animal prey, although other species were also exploited (mainly rodents, birds and cervids). On the basis of this it has been proposed that early hunter–gatherers (before about 7500 ^{14}C BP) practised a generalist subsistence strategy in most regions (see for example García et al., 1999; Miotti and Salemme, 1999; Gil et al., 2008; Gutiérrez and Martínez, 2008).

After the end of this millennium, when FTPPs seem not to have been produced any more in most of Southern Cone, several projectile point types with wide spatial distribution appear in Argentina. In Patagonia, in the central plateau of Santa Cruz province and in the Pinturas river basin, sub-triangular medium-sized stemless points have been recorded at Cueva de las Manos (Gradin et al., 1976) and Cerro Casa de Piedra 7 (Civalero, 2009). These points are persistent in the following millennium in Southern Patagonia and are usually associated with bolas stones and cave painting (the rock art style reflecting communal or collective guanaco hunting, according to Aschero, 2000).

In the Puna desert (Northwest region), small triangular stemless projectile points appeared in this ^{14}C millennium and continued into the next one. They are recorded at the following sites: Alero Cuevas, Los Hornillos 2 (Hoguin and Restifo, 2010); Inca Cueva 4 (Aschero, 1984); Quebrada Seca 3 (Aschero et al., 1991); Pintoscayoc 1 (Hernández Llosas, 2000); Huachichocana CH3 (Fernández Distel, 1980). In Northern Chilean sites these points have a similar chronological distribution (Núñez et al., 2002). On the basis of techno-morphological analysis from Southern Argentinian Puna sites, it has been proposed that these triangular points were thrown with atlatls, probably for opportunistic hunting of camelids (*Vicugna vicugna*) in open grassland (Aschero and Martínez, 2001; Martínez, 2007). The finding of an atlatl hook at the Cerro Casa de Piedra 7 site shows that this hunting weapon was also used by hunter–gatherers during the early Holocerne in Patagonia (Scheinsohn, 2010).

4.5. 9000–8000 ^{14}C BP (ca. 10,200–8900 cal BP)

The database contains records for 43 occupation events (defined on the basis of 62 dates coming from 29 sites) (Supplementary material; Table 5) during this ^{14}C millennium, including 8 from 6 sites in the Central West region, 12 from 7 sites in the Northwest region, 13 from 10 sites in the Pampas, and 10 from 6 sites in Patagonia. These occupations include the first archaeological signal for some subregions: Dry Pampas (Pampas), San Luis mountain range (Central West), intermontane valleys (Central West) and High

Andes (Central West). ^{14}C-dated human occupation from this period or earlier has not yet been detected in the Northeast and Chaco regions, or in the valleys and quebradas and subtropical forest subregions of the North West.

the Pampean region) dated to 8433 ± 84 ^{14}C and 8123 ± 82 BP (Flegenheimer et al., 2010), and the multiple secondary burials from Peñas de las Trampas 1.1 site (Puna, Northwest) which span from 8400 to 8000 ^{14}C BP (Martínez, 2012). These burials consist of two funerary structures (MNI = 6 individuals; 3 in each) associated with garment pieces, a necklace made with non-local seeds, painted leather, net fragments, and a headband made with non-local plant fibre (Martínez et al., 2007, 2010).

Table 5
Dates for the 9–8th ^{14}C millennium BP, including those excluded from the analysis but mentioned in the text.

Site	Lat (South)	Long (West)	^{14}C years	Sigma	Lab. code	Reference
Quebrada Seca 3	−26.0833	−67.4166	8660	80	Beta-77747	Elkin, 1996
Quebrada Seca 3	−26.0833	−67.4166	8640	80	Beta-59929	Elkin, 1996
Quebrada Seca 3	−26.0833	−67.4166	8330	110	LP-267	Elkin, 1996
Peñas de las Trampas 1.1	−26.0175	−67.35	8440	40	UGA-9073	G.A. Martínez et al., 2004
Peñas de las Trampas 1.1	−26.0175	−67.35	8230	30	UGA-4994	Martínez, 2012
Peñas de las Trampas 1.1	−26.0175	−67.35	8210	30	UGA-4998	Martínez, 2012
Peñas de las Trampas 1.1	−26.0175	−67.35	8170	30	UGA-4997	Martínez, 2012
Peñas de las Trampas 1.1	−26.0175	−67.35	8150	30	UGA-4996	Martínez, 2012
Peñas de las Trampas 1.1	−26.0175	−67.35	8140	30	UGA-4995	Martínez, 2012
Peñas de las Trampas 1.1	−26.0175	−67.35	8000	30	UGA-4999	Martínez, 2012
Punta de la Peña 4	−26.0377	−67.3641	8970	60	UGA-9255	Martínez, 2003
La Cueva de Yavi	−22.1166	−65.4666	8420	70	CSIC-887	Kulemeyer and Laguna, 1996
La Cueva de Yavi	−22.1166	−65.4666	8320	260	CSIC-908	Kulemeyer and Laguna, 1996
Hornillos 2	−23.2297	−66.4561	8280	100	LP-757	Yacobaccio et al., 2008
Alero Cuevas	−24.3666	−66.7166	8838	52	AA-71136	López, 2009
Alero Cuevas	−24.3666	−66.7166	8504	52	AA-71135	López, 2009
Cueva Salamanca 1	−26.0227	−67.2563	8100	50	Beta-260687	Martínez et al., 2010
Gruta del Indio	−34.75	−68.3666	8990	80	LP-925	Gil, 2005
Gruta del Indio	−34.75	−68.3666	8920	110	LP-854	Gil, 2005
Gruta del Indio	−34.75	−68.3666	8045	55	GrN-5394	Gil, 2005
Agua de la Cueva	−32.6169	−69.1802	8800	70	Beta-29886	García et al., 1999
Agua de la Cueva	−32.6169	−69.1802	8460	100	LP-1678	Lucero et al., 2006
Agua de la Cueva	−32.6169	−69.1802	8270	90	LP-1662	Lucero et al., 2006
Arroyo Malo 3	−34.85	−69.8847	8900	60	AA-26193	Dieguez and Neme, 2003
Arroyo Malo 3	−34.85	−69.8847	8870	55	NSRL-11723	Dieguez and Neme, 2003
Arroyo Malo 3	−34.85	−69.8847	8580	60	NSRL-11720	Dieguez and Neme, 2003
Alero Los Morrillos	−31.8833	−69.9166	8465	240	GX-1826	Gambier, 1985
Alero Los Morrillos	−31.8833	−69.9166	8255	170	GAK-4195	Gambier, 1985
La Colorada de La Fortuna	−31.8666	−70.0333	8160	160	GAK-4194	García, 2009
Intihuasi	−32.8469	−65.9833	8060	100	P-345	González, 1960
Casa de Piedra 1	−38.1833	−67.1833	8620	190	I-12067	Gradín, 1984
Abrigo Los Pinos			8750	160	LP-684	Mazzanti, 1999a,b
Paso Otero 4	−38.2116	−60.1094	8913	49	AA-87938	Gutiérrez et al., 2011
Arroyo Seco 2	−38.3605	−60.2441	8980	100	TO-1505	Politis et al., 1995
Arroyo Seco 2	−38.3605	−60.2441	8890	90	TO-1504	Politis and Beukens, 1991
Arroyo Seco 2	−38.3605	−60.2441	8461	74	AA-90120	Politis, pers. com.
La Moderna	−37.1344	−60.0763	8356	65	DRI-3012	Politis et al., 2004
Campo Laborde	−37.01	−60.3847	8720	190	AA-55119	Politis and Messineo, 2008
Campo Laborde	−37.01	−60.3847	8080	200	AA-55118	Politis and Messineo, 2008
Laguna de los Pampas	−34.8905	−61.5436	8971	77	AA-90127	Politis et al., 2012
Laguna de los Pampas	−34.8905	−61.5436	8835	83	AA-90127	Politis et al., 2012
El Guanaco 2	−38.6833	−59.65	8507	84	AA-82712	Flegenheimer et al., 2010
El Guanaco 2	−38.6833	−59.65	8411	80	AA-71658	Flegenheimer et al., 2010
El Guanaco 2	−38.6833	−59.65	8433	84	AA-82705	Flegenheimer et al., 2010
El Guanaco 2	−38.6833	−59.65	8123	82	AA-82710	Flegenheimer et al., 2010
Cueva Zoro	−37.8166	−58.6333	8859	64	AA-85687	Mazzia, 2011
El Ajarafe	−37.8666	−58.5333	8787	41	AA-84039	Mazzia, 2011
El Ajarafe	−37.8666	−58.5333	8574	42	AA-84037	Mazzia, 2011
Alero el Verano	−48.7116	−69.1919	8960	140	I-13797-1	Durán et al., 2003
Cueva Grande de Arroyo Feo	−46.9333	−70.5	8610	70	CSIC-515	Alonso et al., 1984–85
Cueva Grande de Arroyo Feo	−46.9333	−70.5	8410	70	CSIC-516	Alonso et al., 1984–85
Cerro Casa de Piedra 7	−47.9552	−72.0947	8920	200	UGA-7383	Civalero and Aschero, 2003
Cerro Casa de Piedra 7	−47.9552	−72.0947	8380	120	LP-399	Velázquez et al., 2010
Cerro Casa de Piedra 7	−47.9552	−72.0947	8362	68	UGA-870	Aschero et al., 2007
Cerro Casa de Piedra 7	−47.9552	−72.0947	8300	115	LP-384	Aschero, 1996
Cerro Casa de Piedra 7	−47.9552	−72.0947	8138	52	UGA-864	Aschero et al., 2007
La Martita Cueva 4	−48.55	−69.25	8050	90	CSIC-506	Aguerre, 2003
Cueva Maripe	−47.8513	−68.9341	8992	65	AA-65179	Miotti et al., 2007
Cueva Maripe	−47.8513	−68.9341	8762	50	AA-65178	Miotti et al., 2007
Gruta de El Manzano	−36.15	−69.7666	8141	44	AA-73201	Neme et al., 2011
Cueva Maripe	−47.8513	−68.9341	8333	63	AA-65174	Miotti et al., 2007

Early human bone dated to this millennium includes specimens from Laguna de Los Pampas (in the northwest of the Pampean region) with ages of 8971 ± 77 and 8835 ± 83 ^{14}C BP (Politis et al., 2012), the human burial from El Guanaco 2 (in the southeast of

A generalist subsistence strategy seems to explain the archaeological record for this ^{14}C millennium, but from this time camelids (guanaco and vicuña) begin to play an increasingly prominent role in the hunter–gatherer economy. In Pampas and Patagonia, this process is accentuated in the following millennia, during which a specialized regional economy develops (Miotti and Salemme, 1999; Gutiérrez and Martínez, 2008). Although most Pleistocene species became extinct during the late Pleistocene, evidences of hunting/scavenging and butchering of giant ground sloth (*M. americanum*) has been recorded at Campo Laborde (Pampas) dating in the range 9000–7500 ^{14}C BP (Politis and Messineo, 2008); and processing evidence of *Eutatus Seguini* was also reported for Paso Otero 4 site (Pampas) which gave ages (on organic matter residues) between 8913 ± 49 (AA-8793) and 7729 ± 48 (AA-85157). Other post-Pleistocene megamammal survivals in this period include *Hippidion saldiasi*, which has been dated to 8850 ± 80^{14}C BP at the paleontological site of Cerro Bombero (Paunero, 2010).

From the technological outlook, several types of projectile point appear in different areas of Argentina between ca. 9000 and 7000 ^{14}C BP, suggesting cultural (technological/stylistic) regionalization. In Southern Patagonia, as was observed for the previous ^{14}C millennium, triangular stemless types remain as the most prevalent morphological type (e.g. at the sites of El Verano, La Martita, Cueva Maripe and Alero Cárdenas, see respectively Alonso et al., 1984–85; Aguerre, 2003; Durán et al., 2003; Hermo, 2008). In Central West both large lanceolate and triangular stemmed projectile points have been recorded in most of the region. The former are usually assigned to one of several specific cultural types, such as La Fortuna and Los Morrillos in San Juan and Mendoza provinces (see Gambier, 1974) and Ayampitín in the Central mountains range (González, 1960; Rivero and Berberián, 2008; Sario, 2008). In Antofagasta de la Sierra (North West region) the early triangular stemless projectile points, probably associated with atlatl (see above), disappeared around 8000 ^{14}C BP and other morphological types (triangular stemmed and lanceolate) appear at several sites, such as Quebrada Seca 3, Peñas de la Cruz 1.1, Cueva Salamanca 1, and Punta de la Peña 4 (Aschero and Martínez, 2001; Pintar, 2008). Some of the lanceolate points could have been used as spearheads in specialized hunting activities such as stalking/ambush of prey. This implies the co-existence of different projectile propulsion systems (atlatl and spear) during the succeeding 8000–7000 ^{14}C millennium (Martínez, 2007).

4.6. 8000–7000 ^{14}C BP (ca. 8900–7850 cal BP)

The database contains records for 41 occupation events (defined on the basis of 65 dates coming from 33 sites) (Supplementary material; Table 6) during this ^{14}C millennium. These include 7 from 7 sites in the Central West region, 7 from 5 sites in the Northwest region, 11 from 8 sites in the Pampas, and 16 from 13 sites in Patagonia. For this period, a new date (ca. 7420 ^{14}C BP) has been obtained from El Infiernillo, Tucumán (Taller Puesto Viejo 1 site). This is the oldest date for human occupation in the valleys area of Northwest region (valleys and quebradas subregion). This date was not included either in the analysis or tables because it has not yet been published in full (Martínez, 2012). No ^{14}C-dated human occupation of this age or older has yet been recognized in the Northeast and Chaco regions.

Table 6
Dates for the 8–7th ^{14}C millennium BP.

Site	Lat (South)	Long (West)	^{14}C years	Sigma	Lab. code	Reference
Quebrada Seca 3	−26.0833	−67.4166	7760	80	Beta-77746	Elkin, 1996
Quebrada Seca 3	−26.0833	−67.4166	7350	80	Beta-59928	Elkin, 1996
Quebrada Seca 3	−26.0833	−67.4166	7220	100	SMU-2364	Pintar, 1995
Quebrada Seca 3	−26.0833	−67.4166	7130	110	LP-269	Elkin, 1996
Peñas de las Trampas 1.1	−26.0175	−67.35	7790	90	LP-1782	J. Martínez, pers com.
Peñas de la Cruz 1.1	−26.1019	−67.3433	7910	100	UGA-10192	Martínez, 2005
Peñas de la Cruz 1.1	−26.1019	−67.3433	7270	40	UGA-9072	Martínez, 2005
Hornillos 2	−23.2297	−66.4561	7760	160	UGA-8722	Yacobaccio et al., 2008
Hornillos 2	−23.2297	−66.4561	7430	80	UGA-7830	Yacobaccio et al., 2008
Cueva Salamanca 1	−26.0227	−67.2563	7620	60	Beta-178225	Pintar, 2008
Cueva Salamanca 1	−26.0227	−67.2563	7550	60	Beta-178224	Pintar, 2008
Cueva Salamanca 1	−26.0227	−67.2563	7500	60	Beta-178223	Pintar, 2008
Cueva Salamanca 1	−26.0227	−67.2563	7410	100	LP-615	Rodríguez et al., 2003
Agua de la Cueva	−32.6169	−69.1802	7450	140	Beta-90140	García et al., 1999
Agua de la Cueva	−32.6169	−69.1802	7420	90	LP-1654	Lucero et al., 2006
Arroyo Malo 3	−34.85	−69.8847	7670	100	LP-783	Neme, 2007
Arroyo Malo 3	−34.85	−69.8847	7660	50	NSRL-11722	Dieguez and Neme, 2003
Gruta de El Manzano	−36.15	−69.7666	7330	150	GAK7259	Gambier, 1985
Gruta de El Manzano	−36.15	−69.7666	7940	45	AA-73203	Neme et al., 2011
Gruta de El Manzano	−36.15	−69.7666	7835	44	AA-73202	Neme et al., 2011
Gruta de El Manzano	−36.15	−69.7666	7190	130	GAK7531	Gambier, 1985
Gruta de El Manzano	−36.15	−69.7666	7110	180	GAK7530	Gambier, 1985
Gruta de El Manzano	−36.15	−69.7666	7070	70	GAK7532	Gambier, 1985
Cueva Delerma	−36.3272	−68.4502	7650	70	LP-1023	Gil, 2005
Cueva El Peñoncito	−29.7666	−68.9	7470	60	CSIC-464	Berberián and Calandra, 1984
Cueva El Peñoncito	−29.7666	−68.9	7080	60	CSIC-463	Berberián and Calandra, 1984
Intihuasi	−32.8469	−65.9833	7970	100	Y-228	González, 1960
Arroyo El Gaucho 1	−31.6833	63.2491	7160	90	LP-1722	González, 1960
El Alto 3	−31.3988	−64.7388	7108	74	AA-68145	Rivero and Berberián, 2008
Casa de Piedra 1	−38.1833	−67.1833	7560	230	I-12159	Gradín, 1984
Lobería 1. Sitio 1			7921	44	AA-77321	Mazzanti et al., 2010
Lobería 1. Sitio 1			7888	54	AA-81062	Mazzanti et al., 2010
Paso Otero 4	−38.2116	−59.1094	7729	48	AA-85157	Gutiérrez et al., 2011
Arroyo Seco 2	−38.3605	−60.2441	7805	85	AA-24050	Politis et al., 2009
Arroyo Seco 2	−38.3605	−60.2441	7800	115	AA-9046	Politis et al., 2009
Arroyo Seco 2	−38.3605	−60.2441	7685	95	AA-19286	Politis et al., 2009
Arroyo Seco 2	−38.3605	−60.2441	7615	90	AA-9048	Politis et al., 2009

Table 6 (*continued*)

Site	Lat (South)	Long (West)	^{14}C years	Sigma	Lab. code	Reference
Arroyo Seco 2	−38.3605	−60.2441	7580	50	Beta-80909	Politis et al., 2009
Arroyo Seco 2	−38.3605	−60.2441	7540	80	AA-24052	Politis et al., 2009
Arroyo Seco 2	−38.3605	−60.2441	7320	90	TO-1506	Politis and Beukens, 1991
Arroyo Seco 2	−38.3605	−60.2441	7043	82	AA-62517	Politis et al., 2009
Arroyo Seco 2	−38.3605	−60.2441	7000	80	TO-1503	Politis and Beukens, 1991
La Moderna	−37.1344	−60.0763	7460	80	TO-2610	Politis and Gutiérrez, 1998
La Moderna	−37.1344	−60.0763	7448	109	DRI-3013	Politis et al., 2004
La Moderna	−37.1344	−60.0763	7010	100	TO-1507-1	Politis and Gutiérrez, 1998
Campo Laborde	−37.01	−60.3847	7750	250	AA-55117	Politis and Messineo, 2008
La Olla 1	−38.9886	−61.3666	7400	95	AA-19292	Bayón and Politis, 1996
La Olla 2	−38.9883	−61.3669	7315	55	AA-7972	Bayón and Politis, 1996
Cueva de las Manos	−47.15	−70.75	7280	60	NOVA-117	Gradin et al., 1976
Alero el Verano	−48.7116	−69.1919	7500	250	AC-0887	Durán et al., 2003
Alero Cárdenas	−47.3	−70.4333	7750	125	AC-497	Alonso et al., 1984–85
Alero Cárdenas	−47.3	−70.4333	7300	200	AC-488	Alonso et al., 1984–85
Piedra Museo, AEP-1	−47.895	−67.8677	7670	110	LP-450	Miotti et al., 2003
Piedra Museo, AEP-1	−47.895	−67.8677	7470	90	LP-850	Miotti et al., 2003
Arroyo Verde 1	−41.9008	−65.0647	7420	90	LP-1551	Gómez Otero, 2007
Cerro Casa de Piedra 7	−47.9552	−72.0947	7920	130	UGA-7381	Velázquez et al., 2010
Cerro Casa de Piedra 7	−47.9552	−72.0947	7060	105	LP-397	Aschero, 1996
Cueva de la Ventana	−48.4430	−68.8241	7970	40	Beta-135965	Paunero, 2003b
Cueva de la Ventana	−48.4430	−68.8241	7665	75	AA-35237	Paunero, 2003b
La Martita Cueva 4	−48.55	−69.25	7940	260	I-11903	Aguerre, 2003
Las Buitreras	−51.7644	−70.1744	7670	70	CSIC-372	Borrero and Martin, 2008
Cueva Maripe	−47.8513	−68.9341	7703	47	AA-65177	Miotti et al., 2007
Cueva Epullan Grande	−40.3891	−70.1944	7900	70	Beta-44412	Crivelli Montero et al., 1996
Cueva Epullan Grande	−40.3891	−70.1944	7550	70	Beta-47401	Crivelli Montero et al., 1996
Cueva Epullan Grande	−40.3891	−70.1944	7060	90	Beta-41622	Crivelli Montero et al., 1996
Cueva Haichol	−38.5833	−70.6666	7020	120	AC-069	Fernández, 1988–90

The earliest evidence of maritime occupation in Argentina is recorded in this period at the sites of La Olla (Pampas) and Arroyo Verde 1 (Patagonia). The La Olla site is a well-preserved site in the southeastern Pampean marine coast. This site is interpreted as the remains of temporary camps or activity areas focused on processing marine mammals, located in the present-day intertidal zone on the edges of a myxohaline marsh and occupied between c. 7400 and c. 6480 ^{14}C BP (Bayón and Politis, in press; Blasi et al., 2012). The second site (Arroyo Verde 1) is a shell midden located in the north of Chubut province. Lithic artefacts and several remains of marine (crab claws, mollusc shells, fish bones and otoliths) and terrestrial (armadillo skulls, an undetermined mammal bone) fauna were recovered at this site (Gómez Otero, 2007). The date obtained (7420 ± 90 ^{14}C BP) shows that the Atlantic coast was occupied by humans before the mid-Holocene marine transgression (Gómez Otero, 2007). The results of the excavations of the lower component of the Imiwaia 1 site (Beagle Channel, Tierra del Fuego) have not yet been published. However, Piana et al. (2011) have recently reported an occupation dated by two samples to ca. 7800 ^{14}C BP. The main feature of this early component is that unlike all overlying and later occupations of the site, which are characterized by coastal adaptations, the evidence from the lowest component suggests an economy focused on terrestrial mammals (*Lama guanicoe*). The stone tool assemblage from the lower component includes a distinctive type of long-stemmed lanceolate projectile point, not found in contemporary lithic assemblages elsewhere in southern Patagonia.

Several human remains from the North West and Pampas regions have been dated to this period. Pre-7000 ^{14}C BP human remains have not yet been detected in Patagonia. The remains from Cueva Epullán Grande (Northern Patagonia, Crivelli et al., 1996) are not considered here, because the radiocarbon date was not made on human bones.

As noted above, in the Puna (North West) two funerary structures with a total of 6 or more individuals at the site of Peñas de las Trampas 1.1 have been dated to ca. 8400–8000 ^{14}C BP (see above and Martínez et al., 2007, 2010). In Pampas, Skeleton 1 from the Monte Hermoso 1 site (Atlantic Coast) has a similar age (ca. 7860 ^{14}C BP; Politis et al., 2009). At this site hundreds of footprints of children, youths and women, were also recorded and dated to between 7125 ± 75 and 6795 ± 120 ^{14}C BP (see Bayón et al., 2011). Arroyo Seco 2 (also in Pampas) contains primary and secondary burials (at least 44 individuals) from the Early–Middle Holocene, with seven dates for this period. The earlier skeletons were found with triangular stemless projectile points within the bodies (Politis et al., 2009). From the marine shore of the Pampas, five human skeletons recovered at the end of the XIX and the beginning of the XX Century were recently dated to between 7623 ± 78 and 7010 ± 60 ^{14}C BP (Politis and Bonomo, 2011); the isotopic signal of these skeletons indicate a mixed diet.

In this period, a specialized regional economy focused on camelid exploitation characterized the hunter–gatherer societies of the Pampas and Patagonia (Miotti and Salemme, 1999; Gutiérrez and Martínez, 2008), and probably also the Northwest. In many cases faunal resources were supplemented with plants, used both for food and for making tools. This is particularly clearly visible in sites in the Northwest (e.g. Quebrada Seca 3, Peñas de la Cruz 1.1, and Cueva de la Salamanca 1; see Rodríguez et al., 2003; Martínez et al., 2010), probably as a result of good conditions of preservation. Moreover, the youngest date for an extinct megafaunal species is of this period: a single event of butchering of *Doedicurus clavicaudatus* (Glyptodontidae) identified at the La Moderna site (Pampas), for which the date is estimated as between 7000 and 7500 ^{14}C BP (Politis and Messineo, 2008).

Projectile point technology shows little change during the two ^{14}C millennia 9000–7000 ^{14}C BP, with a predominance of the stemless triangular type. However new types such as the lanceolate (in some cases referred to as Ayampitín) have been found at several sites, including El Alto 3 (ca. 7100 BP; Rivero and Roldán, 2005), El Gaucho 1 (ca. 7100 BP; Medina and Rivero, 2007), and Gruta de El Manzano (Neme et al., 2011).

5. Statistical analysis

The evidence is considered in aggregate to try to detect temporal trends in the frequency and locations of early human occupation, beginning with the patterns observed after calibrating and summing the dated occupations in this database. Radiocarbon dates from archaeological sites have increasingly often been used as a demographic proxy, based on the assumption that population density is in some way correlated with site size and number and the volume of archaeological remains, and thus with the number of potential samples available for dating (e.g. Rick, 1987; Gamble et al., 2005; Steele, 2010; Anderson et al., 2011). Although such proxy data can provide a useful resource for reconstructing demographic trends in space and over time, the approach still has significant problems (cf. Surovell and Brantingham, 2007; Steele, 2010; Williams, 2012). These relate primarily to biases affecting the sampling of radiocarbon dates in different times and places, and to calibration curve artefacts. Time-dependent attritional loss of archaeological remains may make more recent events seem more abundant, even where the underlying demographic pattern was one of long-term equilibrium (Surovell and Brantingham, 2007). Such attritional taphonomic processes may also vary in their intensity in both space and time, as may depositional processes which reduce visibility of the preserved archaeological record. Without correcting for such factors, archaeologists may infer misleading signals of population growth or of episodic decline from raw frequencies of dated events. Differential research effort focusing on specific sites and survey areas, *fossile directeur* artifact types, regional cultural phases, or periods of transition can also lead to apparent spikes in date frequency reflecting biased allocation of resources for scientific dating, and not past population trends. These issues are discussed qualitatively as they affect the trends reported here, in the concluding section of the paper.

However, the effects of calibration on estimates of event frequencies must also be considered, guarding against the risk that frequencies of events in radiocarbon years may not reflect frequencies of events in calendrical years, because of past variation in atmospheric ^{14}C production rates. This point has recently been made very clearly by Williams (2012), and can be illustrated in this case. Fig. 3(a) shows the summed probability distributions of the occupations in the present database. The distribution has five clear 'spikes' or peaks, but these are not evidence of increased population densities. The spikes are more likely to be artefacts of the calibration curve. To show this, we simulated (using OxCal 4.1's R_Simulate module, Bronk Ramsey, 2009, and the INTCAL09 calibration curve, Reimer et al., 2009) a radiocarbon date for every calendar year in the interval 8000–14,000 cal BP, with a constant (and small) error of radiocarbon measurement of ±25. These simulated dates were then calibrated in OxCal, and calculated the uncertainty in 'true' age as the full 95.4% confidence interval for the calibrated distribution (where this includes two or more separate sub-ranges, the uncertainty was calculated using their combined upper and lower bounds). Fig. 3(b) shows that the peaks in the summed probability plot for occupations in the database align almost perfectly with the times when dates simulated from an underlying uniform distribution will have very low age uncertainty. The spikes or peaks in the summed probability plot are therefore probably merely artefacts of the inflections of the calibration curve.

As a corollary, the trends in numbers of ^{14}C dates and of dated occupations do not correspond to those predicted for sustained human population increase throughout the survey period (Surovell and Brantingham, 2007). During the last four ^{14}C millennia of the survey period, the distribution of dated occupations in the database does not seem to depart markedly from that expected for a sparsely-sampled but uniform event distribution, although this has not been subjected to a rigorous test. To determine whether that appearance of uniformity reflects an underlying long-term equilibrium in population numbers at the country-wide scale, or simply the effects of sample bias, would require a parallel survey of trends in quantities of cross-datable archaeological material such as occupation layers at sites, *fossile directeur* artefacts, etc. (cross-dating involves the assignation of undated material to a time range on the basis of its similarities to material found elsewhere in contexts of known age). However, this is beyond the scope of the present paper.

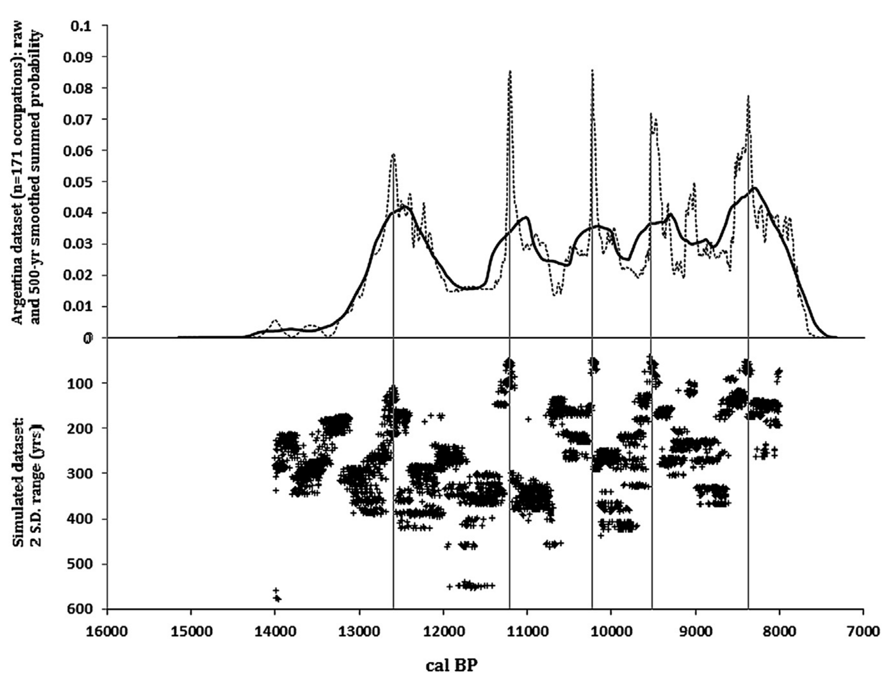

Fig. 3. (Upper graph; (a)): summed probability plot for the occupation events in the database, calibrated in OxCal using INTCAL09, and with a 500-year moving average superimposed. (Lower graph; (b)): uncertainty in the calendar ages of a uniform series of events, based on simulations in OxCal (see text for details). The precise alignment of the peaks in (a) with the periods of very low age uncertainty in the simulated dataset ((b)) indicates that those peaks are probably artefacts of the calibration curve.

6. Conclusion

Despite the several biases mentioned above which can affect the rates of preservation and discovery of ^{14}C samples, some trends can now be provisionally identified. Considered in turn are: (1) regional settlement chronologies, and systematic biases which may distort the archaeological records of different regions and subregions; (2) the significance of early Argentinian ^{14}C dates for the pre-Clovis debate; and (3) the contribution of Argentinian archaeological ^{14}C dates to a better understanding of the megafaunal extinction chronology.

Firstly, early archaeological ^{14}C dates from Argentina show geographical patterning in their distribution. Most early occupation evidence comes from the eastern Pampas (mainly the Interserrana area and the Tandilia hill range) and from southern Patagonia (mainly the Deseado Plateau). This may reflect the actual distribution of early populations, but it may also reflect research orientation bias and the visibility or level of preservation of the early archaeological record. On the one hand, during the late Pleistocene–early Holocene, these regions offered extensive plains for hunting large mammals, notably in the Deseado Plateau in Patagonia, and the Interserrana area of the Pampas, and would therefore have been preferred areas for large-mammal hunters. Additionally, good quality lithic raw material is available in both areas (or very close by). Both factors would have promoted these areas as preferred places for human occupation during the Late Pleistocene. On the other hand, several factors also make these areas likely to have above-average preservation and/or visibility of the early archaeological record. In the Pampas, the extensive deposits of loess of Late Pleistocene age generate an appropriate sedimentary context to preserve early sites; river cuts, gullys and banks then expose these archaeological sites, which may be buried under several metres of Holocene sediments (e.g. Paso Otero 5). In Patagonia (especially in Deseado Plateau) and in the Pampas (Tandilia system), rock shelters (caves and overhangs) are also abundant. These geoforms have three archaeologically relevant properties: a) they were preferred places for human occupation, b) their interiors usually offer good conditions for stable sedimentation and preservation of archaeological contexts, and 3) they are easily detectable by archaeologists. Both areas are also among the more intensively studied for the Late Pleistocene Period. Therefore, the high frequency of ^{14}C dates in the Interserrana-Tandilia areas and in the Deseado Plateau could reflect both early human occupation concentration, and contemporary biases in archaeological preservation, discovery, and allocation of research effort (see Borrero and Franco, 1997 and a similar case in Méndez, in this issue).

Unlike Pampa and Patagonia, in the Chaco and Northeast regions early archaeological sites have not yet been detected. Fig. 4 shows the proportions of the sites and dates in database for each region and for the whole period covered, with reference to each region's surface area. It is clear that the Chaco and the Northeast are under-represented regions for their surface area. It is possible that this lack of evidence is partly due to sampling bias. In the east sector of the Uruguay River, in Uruguay, where systematic investigations in late Pleistocene deposits have been carried out, a clear signal of human presence has been detected at ca. 11,000 ^{14}C BP (Suárez, 2011). Abundant FTPPs have been recovered in Uruguay (see López Mazz, in this issue; Castiñeira et al., 2011) suggesting that humans had already settled there by ca. 10,500 ^{14}C BP, and there have been two instances of undated FTPPs recorded at sites in the Northeast region of Argentina (see above). However, in Chaco and in the Northeast, good quality lithic raw material is scarce, which in turn would reduce the preservation and the visibility of archaeological assemblages. In the Northeast, high humidity and distinctive soil chemistry also create an unsuitable context for bone preservation. Additionally, in these two regions archaeological research has been less intensive and has been focused on the later periods (when pottery is abundant); both regions lack rock shelters, which are good conservators of archaeological remains; and thick Holocene sedimentation and continuous vegetation covers most of these areas reducing significantly the visibility of the early archaeological sites. Therefore, it cannot be confidently stated that the current absence of evidence for early human occupation in Chaco and the Northeast between 12–7000 ^{14}C BP is evidence of its absence.

Some of the same problems would affect the record of human occupation in several other regions or subregions. In the Dry Pampas and in Northern Patagonia, dense forest cover and thick loess and alluvial Holocene sedimentation can also drastically reduce archaeological visibility (see for example Prates, 2008; Martínez and Martínez, 2011). In periglacial areas in the Andes Cordillera, Late Pleistocene /Early Holocene sites may also have been disturbed by de-glaciation processes (Neme, 2002; Neme and Gil, 2008).

In other regions such as the eastern slope of the Andes in Patagonia (e.g. the Andean range and foot hills, Salemme and Miotti, 2008, and the North Patagonian Andean forest lakes), in the peri-Andean Central West (Mendoza and San Juan Andes), and in the Northwest (e.g. the Puna region), the first archaeological evidence of occupation appears somewhat later. In these regions there has been intensive archaeological research for an extended period, and there are no systematic factors (except perhaps the preservation of surface assemblages on deflated surfaces) which are likely to reduce archaeological visibility. The weak archaeological signal could therefore be a genuine indication of a late colonization of these areas, which might be considered more marginal environments (see discussion in Borrero, 1994–95; Neme and Gil, 2008; Salemme and Miotti, 2008).

Turning to the pre-Clovis debate, the archaeological signal of human occupation in the thirteenth and earlier twelfth ^{14}C millennia BP (13,000–11,000 ^{14}C BP) is suggestive but sparse, and weak. For some authors, this is a typical record of an exploratory phase (see for example Borrero, 1994–95 for the case of Patagonia). However, from about 11,000 ^{14}C BP there is a consistent archaeological signal with the earliest occupations concentrated in two main areas: the Tandilia–Interserrana area in the Pampas and the Deseado Plateau in Patagonia. Only two sites are located outside the Pampas and Patagonia (Agua de la Cueva and Gruta del Indio) within this period. Between 10,700 and 10,400 ^{14}C BP, well-dated fishtail projectile points appear in sites in the Pampas and in Patagonia. In the whole of South America, the only three older dates possibly associated with this type of projectile point have large statistical age uncertainties (11,000 $\pm$ 170 ^{14}C BP from Fells Cave, Chile; 10,930 $\pm$ 230 ^{14}C BP from Cueva del Medio, Chile; and 11,150 $\pm$ 135 ^{14}C BP from Cerro La China II, Argentina). Overall, it is clear that FTPPs are younger than Clovis and that there is little or no temporal overlap between them. Therefore the recent statement that "dates for Fishtail or Fell I sites (with fluted, stemmed points) in southern South America are statistically indistinguishable from Clovis dates in North America" (Fiedel and Kuzmin, 2010: 337) should be re-evaluated. In terms of geographical distribution, undated fishtail projectile points have been recorded in a great diversity of environments (including the Northwest, Northeast, Central West, Pampas and Patagonia regions of Argentina). These isolated finds support the premise that most of the Argentinian territory was occupied at the time when this technology was in use (ca. 10,700–10,400 ^{14}C BP).

Extinct mammals (*Mylodon* sp., *Eutatus seguini*, *Hemiauchenia* sp., *Hemiauchena* cf. *paradoxa*, *Toxodon* sp., *Glossotherium* sp., *Megatherium americanum*, *Equus neogeus*, *Hippidion* sp., *Hippidion*

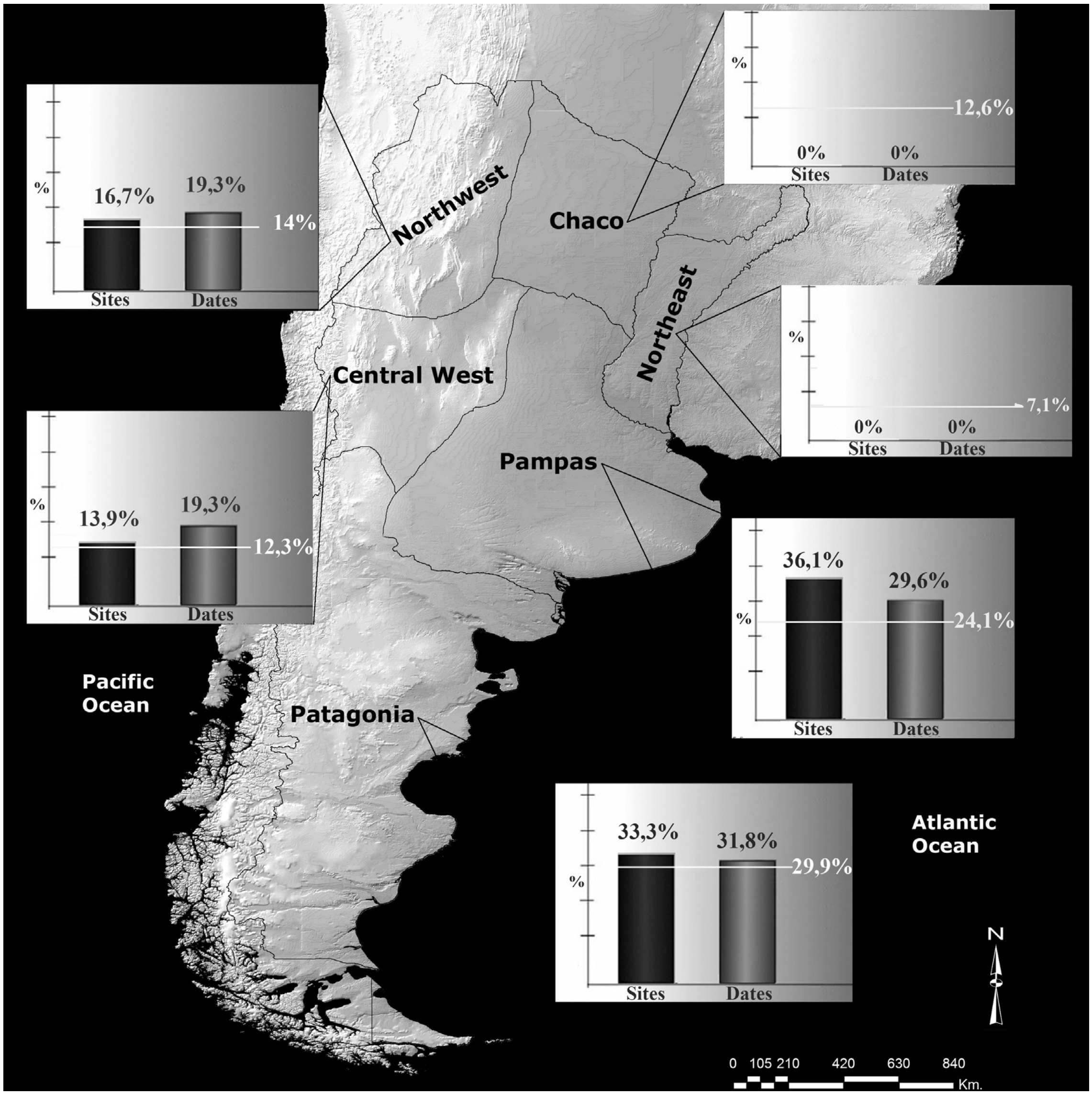

Fig. 4. Percentages of sites in database (black column), percentages of dates (gray column), and percentages of the total area (white line) for each region of Argentina.

saldiasi, *Lama gracilis*) are found in layers also containing cultural evidence, suggesting that some of these taxa survived in the Pampas and Patagonia until the 11,000–10,000 ^{14}C BP period or later. Megafaunal remains are present in layers associated with 23 of the occupations in the database. At some sites direct evidence of human agency has been identified on the bones themselves (e.g. Arroyo Seco 2, Paso Otero 4, Paso Otero 5, Campo Laborde, Piedra Museo, Casa del Minero 1, El Trébol) while at other sites, either there is no such evidence (e.g. Cerro La China 1, El Sombrero C1, Cueva Tixi), or the evidence is unclear (e.g. Gruta del Indio). The importance of megamammal exploitation in the subsistence of Late Pleistocene societies in the Pampas and Patagonia is still difficult to determine and is subject to debate (Politis and Messineo, 2008; Borrero, 2009; Martínez and Gutiérrez, 2011). In some sites, such as Campo Laborde and La Moderna, megamammals are the most abundant prey class, but this may not be typical of the wider picture, as these sites have been interpreted as kill/processing sites. At sites elsewhere which appear to have had more prolonged occupation and greater diversity of activities, such as Cerro La China, Paso Otero 4, Cueva Casa del Minero 1, or Piedra Museo, Pleistocene mammals only represent a small part of the bone assemblage, suggesting they were a secondary and minor resource.

It also seems clear that in the Pampas some Pleistocene megamammals survived until early Holocene times. This means that there is a chronological overlap of ca. 3000–4000 ^{14}C years, when humans and several megafaunal species coexisted in the Pampas. These observations seem inconsistent with the “overkill hypothesis” and suggest (*contra* Steadman et al., 2005) that giant ground sloth survived up to several millennia in the Pampas after human arrival. The recent date of ca. 8850 ^{14}C BP (*Hippidion saldiasi*) in South Patagonia (Cerro Bombero, Paunero, 2010) and ca. 9500 ^{14}C BP on sloth dung and Mylodon skin in the Central West region (Gruta del Indio; Gil and Neme, 2010) suggest a similar pattern in both regions.

Finally, the data summarized here from Argentina do not support a great antiquity (pre-Late Glacial Maximum) for the peopling of the Southern Cone of South America, and indicate that earliest settlers did not have a bifacial projectile point technology. Humans were certainly present in this region at the time of the North American Clovis culture, and may have been present one ^{14}C millennium earlier. A strong archaeological human signal is clearly detected after 11,000 ^{14}C BP, and subsequent expansion from around 10,700 ^{14}C BP may have been associated with a new technology which included, among other artifacts, the fishtail projectile point.

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Appendix A. Supplementary material

Supplementary material related to this article can be found at http://dx.doi.org/10.1016/j.quaint.2013.03.011.

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