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Terminal Pleistocene/early Holocene ^{14}C dates form archaeological sites in Chile: Critical chronological issues for the initial peopling of the region

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ABSTRACT

A review of ^{14}C information for archaeological sites in Chile between 13,000 and 7000 BP assesses the consistency of information on the early settlement of the region. Results explore geographical distribution, contextual reliability, repeatability and cultural association of this assemblage of dates. Chronological trends are discussed through the use of averaged calibrated occupational events based on contextual and statistical data. The use of this database constitutes the framework for discussing critical issues such as the first consistent human presence, regional temporal peopling differences, the chronological data supporting consistent use of littoral environments, and the coexistence/interaction of extinct faunas and humans. Research biases and current unsolved questions are raised in order to formulate a future agenda for improving chronological data for the human occupation of the Pleistocene-Holocene transition in Chile.

1. Introduction

Building an archaeological ^{14}C database is critical for assessing the reliability of data when studying the initial settlement of a region because it provides means to measure the presence of persistent and demographically-viable hunter-gatherer populations (Steele and Politis, 2009), as well as the keys for evaluating long-term responses to climate (or other) changes (Gamble et al., 2004; Buchanan et al., 2008) and estimating the rates of population dispersals (Steele, 2010). Without a critical assessment of ^{14}C information, the discussion generally relies on data difficult to compare or even the use of exceptional dates as chronological markers of the peopling process, rather than average trends. The larger the number of radiocarbon dates used, and the larger the area sampled, the more likely that changes in frequency may be informative of regional-based population fluctuations, and the basis for estimating the chronology of the peopling of an area. ^{14}C database compilation and filtering data quality should allow not only improved information transference, but also is highly significant for discussing the peopling of America. Such discussion has recently been carried out with precise information for North America (Waters and Stafford, 2007; Steele, 2010; Gajewski et al., 2011). However, a dataset with chronological information for South America is currently unavailable, as is the case for Chile. Radiocarbon information for such a dataset is dispersed in several publications (usually not widely available), with uneven information, or such data remains unpublished.

This paper contributes to the above task, as it sums up the radiocarbon dates between ~13,000 and 7000 BP or ~16,500 and 7700 cal BP in Chile. Results draw on the geographical distribution of these "early" ^{14}C ages, their reliability, date repeatability within sites, and archaeological context associations. Among other subjects, it discusses (1) the age for the first consistent human presence in the region; (2) the spatial and temporal distribution of dates and occupation events in order to explore peopling differences and sampling biases; (3) the chronological data associated with coastal archaeological evidence; and (4) the coexistence of extinct faunas and human beings. Discussing these subjects is of high significance in the wider regional setting because ^{14}C data in Chile includes Monte Verde, the earliest widely accepted site of the Americas (Dillehay, 1989, 1997), which currently stands alone as an exception to the general chronological trends documented in the vicinity and in most of South America (Goebel et al., 2008).

2. Regional setting and paleoclimates

Chile is a long (17°30′–55°58′ S) and extremely narrow (75°40′–67° W) land, located along the southernmost western

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slope of South America, covering roughly 24% of the Pacific coast of the continent (4300 km). It is limited by the ocean to the west and south, and the Andean mountain range to the east, thus constituting a remarkable biogeographical corridor, suitable for exploring population dispersals along its north-south axis. A wide variety of climates and ecosystems occur along the region as result of interactions between atmospheric circulation and topographic patterns (Garreaud et al., 2009). Noteworthy is the latitudinal change in precipitations regimes, with extremely arid conditions to the north and hyperhumid conditions to the south (Romero, 1985), thus allowing the development of deserts and moorland vegetation, respectively (Luebert and Pliscoff, 2006). These climatic features respond to: (1) the Easterlies producing summer precipitations in the highlands of northern Chile, (2) inter-annual changes in the Pacific Anticyclone activity which influences the Westerlies' flux (e.g. latitudinal position and intensity) between ~26°–41°S, and (3) the permanent influence of the Westerlies south of 41° S (Romero, 1985). Two major geographic aspects influence climate in the region: the ameliorating effect of the Pacific Ocean and the position of the Andes along the whole territory, imposing an abrupt increase in altitude from west to east. Such a geographical north-to-south distribution makes it straightforward to compare data in a latitudinal manner. This paper uses a five-biogeographical division as means to organize data. This includes the Arid North zone (~17°30′–26° S), the Semiarid North zone (~26°–32° S), the Mediterranean zone (~32°–38° S), the Southern zone (~38°–42° S), and Patagonia (~42°–56° S). This division has proven appropriate for understanding broad climatic processes and is widely accepted in Chile as a framework for explaining archaeological distributions (Hidalgo et al., 1989).

Selected paleoclimate records can be used for examining broad trends that may have affected population dynamics during the initial regional exploration. In general, these records suggest an almost synchronous beginning of the Last Glacial Interglacial transition at ~18,000–17,000 cal BP, characterized by an increase in temperatures which allowed the expansion of vegetation to areas previously occupied by the ice (Latorre et al., 2007). During the Pleistocene Holocene transition, changes from wetter-than-today towards drier Holocene conditions have been documented from the Arid North zone through the Mediterranean zone. However, regional trends differ both on a temporal scale and regarding how those changes occurred. In the Arid North zone, wet to very wet terminal Pleistocene conditions have been recorded through several paleoclimatic archives (including rodent middens, lake sediments, paleo-wetland deposits) lasting until ~9000 cal BP, when a shift towards drier-than-today conditions is inferred (Rech et al., 2002; Grosjean et al., 2007). In the Semiarid North zone, the Quebrada Santa Julia pollen record shows that terminal Pleistocene wetter-than-today conditions persisted until ~11,200 cal BP when the general trend towards drier Holocene conditions started (Maldonado et al., 2010). However, wetland expansions inferred at ~10,500 and 9200 cal BP are suggestive of increased available regional moisture, implying that the shift towards drier conditions was not a unidirectional process. This step-wise transition mode is in agreement with changes in sea-surface temperatures inferred for the Pleistocene–Holocene transition in the Mediterranean zone (Kim et al., 2002). In this zone, inland paleoclimatic records (pollen, sediments, geomorphology) and paleontological assemblages at Laguna Taguatagua are suggestive of wetter/cooler-than-today conditions lasting until ~13,800 cal BP and significantly shifting towards drier conditions at ~11,800 cal BP (Valero-Garcés et al., 2005). In the Southern zone, late Pleistocene hyperhumid conditions prevailed until ~15,700 cal BP when conditions approaching modern-day climate were inferred from the Huelmo pollen record as consequence of latitudinal shifts in the Westerlies (Moreno and León, 2003). However, significant reversals were observed at ~15,000 cal BP and abruptly at ~13,700 cal BP and lasted until ~12,000 cal BP, when the warming/drying process started again. On the other hand, evidence from Patagonia is largely influenced by the extension of glaciers covering large portions of the currently forested Andean mountain range. Areas available for human beings were mostly limited to the east of the massif, constituting "dead ends" for population dispersals (Borrero, 2004). Harsh drier-than-today conditions within this periglacial environment have been recorded for the Pleistocene Holocene transition with changes towards higher temperatures at ~17,500–17,150 and ~11,450 cal BP (McCulloch et al., 2000). Despite the recurrent identification of "cold-reversal" events prior to the onset of the Holocene, their timing and characteristics is still a matter of debate (Bennett et al., 2000; McCulloch et al., 2000).

3. Materials and methods

The ^{14}C ages recorded in the database were obtained from archaeological sites in Chile framing the Pleistocene Holocene boundary (~13,000 to 7000 BP). The search prioritized published ages; however it included some exceptional cases, particularly when there was firsthand knowledge of the collecting context. All ages were recorded in years before present (BP) and were calibrated (cal BP) with Calib Rev 6.0.1 (Stuiver et al., 2005). No previous calibration provided by the authors consulted was used in order to even the data. Throughout the paper, dates were calibrated with IntCal09 (Reimer et al., 2009) and ranges are expressed at 2-sigma confidence level.

The database includes attributes such as: site reference, regional distribution (sites and dates >7000 BP in Chile and additional references are presented in a supplementary online file), geographical location, altitude, distance to the current coastal line, stratigraphic and context information, laboratory codes, ^{14}C value plus sigma, $\delta^{13}C$ value, 1σ and 2σ calibration, calibrated medians, material dated, type of association to anthropogenic evidence, dating method, and first and/or most complete reference. Other information such as: general cultural (i.e. culture complex, artifact-type) affiliations (following the references consulted), site-type, and faunal assemblages coupled to the radiocarbon dates was also considered. Such information is markedly uneven and occasionally incomplete, depending on a wide variety of factors (i.e. paradigmatic issues, completeness in the publications, state of progress in the research, etc.). The latter is particularly true regarding dates obtained earlier in Chilean archaeology. Some of the observations include inconsistencies regarding laboratory codes, dates wrongly associated with sites, differing information on laboratory errors, and others. These problems were addressed by assessing the reliability of dates and are discussed below.

In order to critically assess some of the issues raised, the bias introduced by ^{14}C date-rich sites by defining occupation events had to be minimized. Events were calculated considering only the ages directly associated with archaeological layers, and dates that were not previously rejected by the researchers who studied the sites. The number of events calculated throughout the paper should be regarded as a "minimal number of events". Whenever two or more dates had the exact same provenance (for instance: charcoal/shell coupled samples), the most reliable dating material (i.e. charcoal) was selected. For the remainder of the dates, events were calculated by averaging ^{14}C results from a single site whenever they were statistically indistinguishable at $\alpha = 0.05$ (Ward and Wilson, 1978). The only exceptions were direct analyses on human remains which were considered as independent occupation events due to the contextual nature of this type of early archaeological evidence. Calibrated medians of dates and of events were used in order to discuss temporal trends within millennial and sub-millennial intervals. A general summed probability plot yielding all

compiled data and zonal summed probability plots (Calib Rev 6.0.1) were used for reviewing and comparing chronological trends in occupational events.

4. Results

Currently, the database includes 326 ^{14}C ages, from 81 archaeological sites, unevenly distributed along Chile (Fig. 1). As several dates obtained were not directly related to the anthropogenic deposits at the sites (for instance dates of strata over or below human occupations), the first screening consisted on discerning whether the dates were associated with the archaeological record, thus appropriate for understanding human activity. In the database, 77.30% ^{14}C ages are associated with anthropogenic layers at the sites. The others either are not associated (17.79%), ambiguously associated (3.68%), or the information was unavailable (1.23%; Table 1). The sample was further screened in order to include in the discussion only the most reliable dates by excluding those that, despite being associated with anthropogenic deposits, had been previously challenged due to unusually large sigma, contextual factors or contamination. Regional temporal trends are assessed considering a total of 235 ^{14}C ages that were used for calculating 155 occupation events.

4.1. Reliability and repeatability

One significant measure for assessing dating reliability is the method applied in the analyses. Considering all dates recorded, the distribution in this sample is significantly even between ^{14}C conventional ages ($N = 107$; 32.82%), ^{14}C AMS ages ($N = 116$; 35.58%), and cases where no information was available ($N = 103$; 31.6%). The improvement of dating methods, such as the current generalized use of ^{14}C AMS dating technique, and quality of reporting the data constitutes a renewed tendency. However, information on δ^{13}C values associated with ^{14}C ages is infrequently available, being only reported in 25.08% of all the analyses.

Materials dated also reflect selective choices while seeking reliable data. Although charcoal (39.18%), usually obtained from hearths or burning activity at sites, and bone collagen (22.88%, either human or animal) comprise most of the sample, other specific types of materials deserve some explanation. Marine shell, with 10.97% of the ^{14}C ages recorded, is one of the most common choices, despite the fact that such results are subject to reservoir effect. Currently there is insufficient data to measure that effect in a regional basis (Ortlieb et al., 2011; 14CHRONO marine reservoir database, 2012). The main cause for selecting marine shell as dating material is the high frequency of shell midden sites near the coastal margin which couples with strong sea-wind deflation in such locations, making charcoal and other organic material survival significantly difficult. Organic sediments (5.96%) and terrestrial macrobotanical remains (4.7%) are also common choices, but they have been usually used in dating deposits not directly associated with the archaeological record, or rodent middens located in cave/rockshelter sites. These dates have served either for bracketing the human occupations or for using archaeological sites as paleoenvironmental archives.

The amount of ^{14}C dates per site is a measure (repeatability) to assess the accuracy of the chronological data (Faught, 2008). Only in this case were all dates considered, not only the ones associated with anthropogenic evidence, because dating other materials than those directly associated generally improves the quality of the data (i.e. stratigraphic integrity). Table 2 shows regional distribution of the frequency of dates per sites and which specific sites yielded the highest amount of ^{14}C dates, thus being the most thoroughly scrutinized. Results are significantly uneven. Although the Arid North zone comprises the highest number of dated sites, Patagonia yields the highest proportion of sites with more dates. On a site-by-site basis, Baño Nuevo 1 (Mena and Stafford, 2006), located within the latter zone, stands as the most thoroughly dated archaeological site in Chile, especially considering the ages younger than 13,000 BP. On the other hand, the general trend is for most sites to yield a small amount of dates, as for 37.04% of the sample, which represents sites with no repeated ^{14}C analysis. Also, the younger the site, the fewer dates it yields, which is probably due to the high scrutiny to which the earliest sites are generally subjected, as opposed to the lesser degree of attention that later human occupations receive.

Repeatability is a crucial factor in this discussion, mainly because the earliest ^{14}C date at a site is not necessarily the most accurate age for its initial occupation. This is true in several cases presented here, where series of assessments have yielded consistent averaged dates which are generally younger than the oldest date within the same deposit. For instance, at Monte Verde II site (Southern zone), the most consistent published dates range between 14,600 and 14,200 cal BP (Dillehay and Pino, 1997; Dillehay et al., 2008), but outliers reach values of 15,430–17,180 cal BP (Lab# TX 3208). A similar case could be argued for Cueva del Medio (Patagonia), where despite a 13,910–15,110 cal BP (Lab# PITT 4303) age, a consideration of 17 dates associated with the archaeological deposit (Nami, 1987; Nami and Nakamura, 1995) allow more conservative averaged events which can be placed around 10,800–11,250, 12,140–12,560, and 12,630–13,050 cal BP. These ages are consistent with general temporal trends for the earliest human presence in southern Patagonia (Steele and Politis, 2009; Prates et al., submitted for publication). What has been learned from the research at sites such as Monte Verde II, Cueva del Medio, and Baño Nuevo 1 is that only series of multiple dates can offer higher degrees of confidence in assessing the initial human signal within a site.

4.2. Data structure

Early dates from archaeological sites recorded in Chile span from $33{,}370 \pm 530$ BP (36,690–39,260 cal BP) to 7000 ± 40 BP (7730–7940 cal BP). The oldest age corresponds to burned wood from Monte Verde I site (Dillehay and Pino, 1997). However, defendable and consistent human activity has a more limited time span. It can be appropriately discussed from ~13,000 BP or ~15,600 cal BP onwards, a period where all widely accepted dated early sites fall. Descriptive data presented in this section are graphed on Fig. 2, which includes medians of the total number of dates and occupational events recorded per region in a sub-millennial scale. While these could be seen as regional peopling tendencies, at least some of the observed trends are affected by research biases. For instance, Patagonia and the Arid North zone yield together 58.73% of all available dates, 70 (38 events) and 68 (50 events), respectively. These areas have long been studied, multiple research teams have undertaken excavations at early sites, and the initial peopling has been a recurrent issue among researchers. This is especially true for southernmost Patagonia where, for instance, research at Fell's Cave was carried out during the early XX Century (Bird, 1993), and ever since seeking for terminal Pleistocene-early Holocene sites has been a persistent aim, conceivable as a long-term research program. On the other hand, regions as the Southern zone have long been devoid of archaeological hunter-gatherer research, and thus the paucity of ^{14}C dates is a reflection of this particular situation. In this last case, excluding the ^{14}C data from Monte Verde II, only other six dates were obtained at other sites for the period in question. Chronological data are ordered by millennial intervals using calibrated dates and median values.

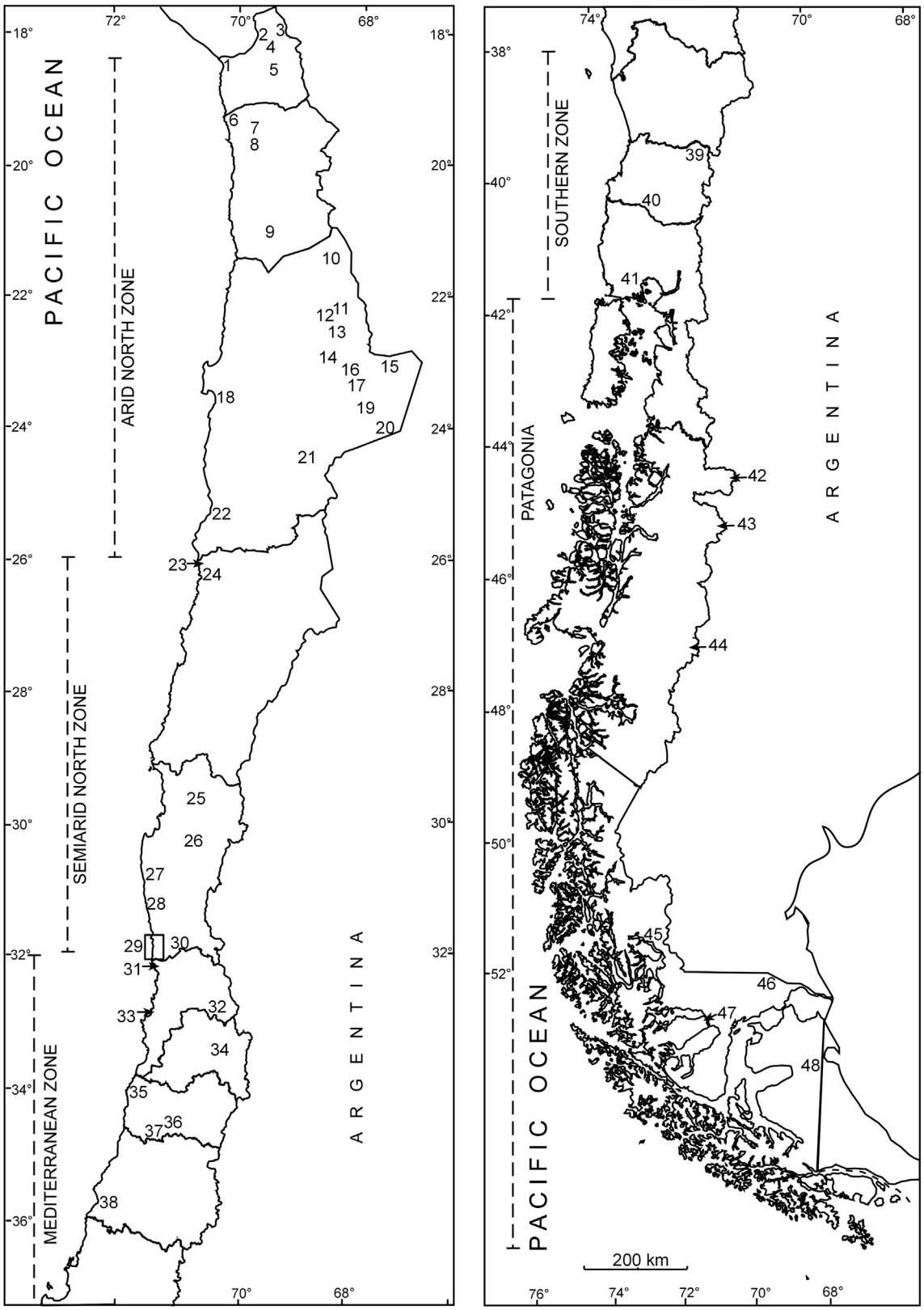

Fig. 1. Map of Chile showing the sites with dates earlier than 7700 cal BP; 1. Acha 2, 3 & 4, Morro 1; 2. Patapatane; 3. Hakenasa; 4. Las Cuevas; 5. Tojotojone; 6. Camarones 14; 7. Tiliviche 1b; 8. Aragón 1; 9. Quebrada Blanca; 10. San Martin 4; 11. Chulqui 1; 12. Alero Toconce; 13. Tuina 1 & 5; 14. Alero El Pescador; 15. Aguas Calientes; 16. Tambillo 1; 17. San Lorenzo 1; 18. La Chimba 13 (former Las Conchas); 19. Tulan 67, 68 & 109; 20. Tuyajto 1b; 21. Punta Negra 1 & 6; 22. Cascabeles 226-5; San Ramón 15; 23. El Obispo 1; 24. Los Médanos 2; 25. La Fundición 1; 26. San Pedro Viejo de Pichasca; 27. El Teniente; 28. Huentelauquén; 29. Los Vilos area: Punta Ñagué (LV 098a), Quebrada Santa Julia (LV 221), Punta Penitente (LV 014), Punta Chungo (LV 046b), Los Rieles (LV 036), Quebrada Quereo, Quereo Perfil (2b), Quebrada Lazareto (LV 089), Surprise (LV 207), Punta Purgatorio (LV 079 & LV 080), and Pichidangui (LV 531); 30. Valiente (CT 14); 31. El Chivato; 32. Piuquenes; 33. Punta Curaumilla 1; 34. El Manzano 1 & 3; 35. Paso de las Conchas; 36. Cuchipuy; Taguatagua 1 & 2; 37. La Patagüilla; 38. Plaza de Pelluhue (07Pe010); 39. Loncoñaco 2; Marifilo 1; 40. Río Bueno; 41. Monte Verde II, Chinchihuapi; 42. El Chueco 1; 43. Baño Nuevo 1; 44. Alero Entrada Baker; 45. Cueva del Medio, Lago Sofía 1; 46. Cueva Fell, Pali Aike; 47. Ponsonby; 48. Tres Arroyos 1.

Table 1
Regional distribution of ^{14}C dates in the database and types of associations.

Region	Associated with archaeological deposit	Ambiguous association	Not associated with archaeological deposit	No data	Total
Arid North zone	73 (22.39%)	–	15 (4.60%)	2 (0.61%)	90 (27.61%)
Semiarid North zone	43 (13.19%)	4 (1.23%)	9 (2.76%)	1 (0.31%)	57 (17.48%)
Mediterranean zone	33 (10.12%)	–	1 (0.31%)	–	34 (10.43%)
Southern zone	22 (6.75%)	2 (0.61%)	12 (3.68%)	1 (0.31%)	37 (11.35%)
Patagonia	81 (24.85%)	6 (1.84%)	21 (6.44%)	–	108 (33.13%)
Total general	252 (77.30%)	12 (3.68%)	58 (17.79%)	4 (1.23%)	326 (100.00%)

4.2.1. >13,000 cal BP (>11,100 BP)

Dates earlier than 13,000 cal BP have only been recorded at Monte Verde II, Chinchihuapi, and Taguatagua 1. The first two sites are located close to each other around 41°30′ S. Monte Verde II, an stratified open-air site, yielded 15 ages within this interval (Dillehay and Pino, 1997) comprising a total of four occupational events extending from 15,430–17,180 to 14,050–13,690 cal BP. The outstanding preservation of organic remains at the site, including bones, wood, cordage, and hide, in association to lithic artifacts (Dillehay, 1989, 1997), has challenged the traditional view of early archaeological assemblages and the timing of human presence in the Americas (Dillehay, 2000). Located in the vicinity, the slightly younger Chinchihuapi site yielded one date (14,030–15,070 cal BP) associated with a small tool assemblage including wooden artifacts (Dillehay and Pino, 1997). Regarding Taguatagua 1, although two dates fall partially within this interval, they yielded significantly large sigma (≥300 years; Montané, 1968; Núñez et al., 1994), requiring their averaged calibrated values to be considered within the limits of the next millennial interval. Hence, it is noteworthy that after the youngest Monte Verde II occupational event (averaging 5 dates), no other sites in Chile have defendable ^{14}C ages for ~860 calibrated years.

4.2.2. 13,000 to 12,000 cal BP (~11,100 to 10,250 BP) interval

For all zones, except the Southern zone, the earliest recorded occupations appear during this interval. Dates within this time frame consistently appear at the start of the interval (Fig. 3), thus suggesting that ~13,000 cal BP should be considered an appropriate marker for the onset of hunter-gatherer populations in most areas in Chile. A total of 48 ^{14}C dates comprise 20 occupational events recorded at 18 sites. The Arid North zone yielded six events (out of 7 ^{14}C ages), each recorded at one site. Despite being the earliest occupation in the region, the 10,756–14,211cal BP age (Lab# SI 3112) from Tuina 1 (Núñez, 1983) should be considered cautiously on account of its large-sigma value (±630), thus leaving the Tulan 109 occupational event at 12,020–12,780 cal BP as the earliest reliable candidate (Núñez et al., 2002). Both are caves (≥3000 m asl) with small triangular Tuina pattern projectile point assemblages, occupied during times of strong climate change, although wetter-than-today conditions prevailed (Núñez et al., 2002). Dates on charcoal for this zone should be considered cautiously because old wood fragments are exceptionally preserved in desert environments, and may serve as potential fuel. In the Semiarid North zone, a total of seven events (out of 12 ^{14}C ages) have been recorded at six sites. The earliest date is the 12,720–13,170 cal BP occupational event at Punta Ñagué site (Jackson and Méndez, 2005). However, the material dated was marine/estuarine shell uncorrected for local reservoir effect, and should be disregarded as a reliable candidate. On the other hand, Quebrada Santa Julia (3 km distant) provides more accuracy in setting the chronology of its anthropogenic layer because three ^{14}C

Table 2
Date repeatability at archaeological sites in Chile. considering all ^{14}C ages in the database. Specific sites with >5 ^{14}C ages are mentioned.

Region	Dates per site	Specific sites (dates per site)	# of sites
Arid North zone	1 ^{14}C age		12
	2 to 5 ^{14}C ages		14
	>5 ^{14}C ages	Hakenasa ($N=9$)	5
		San Ramón 15 ($N=6$)	
		Salar de Punta Negra 1 ($N=7$)	
		Tuina 1 ($N=9$)	
		La Chimba 13 (former Las Conchas) ($N=13$)	
Semiarid North zone	1 ^{14}C age		10
	2 to 5 ^{14}C ages		8
	>5 ^{14}C ages	Huentelauquén ($N=6$)	3
		Quebrada Santa Julia ($N=6$)	
		Quebrada Quereo ($N=9$)	
Mediterranean zone	1 ^{14}C age		2
	2 to 5 ^{14}C ages		8
	>5 ^{14}C ages	Piuquenes ($N=8$)	1
Southern zone	1 ^{14}C age		3
	2 to 5 ^{14}C ages		1
	>5 ^{14}C ages	Monte Verde ($N=31$)	1
Patagonia	1 ^{14}C age		3
	2 to 5 ^{14}C ages		4
	>5 ^{14}C ages	Ponsonby ($N=6$)	6
		Cueva Fell ($N=7$)	
		Lago Sofía 1 ($N=9$)	
		Tres Arroyos 1 ($N=11$)	
		Cueva del Medio ($N=21$)	
		Baño Nuevo 1 ($N=40$)	
Total sites			81

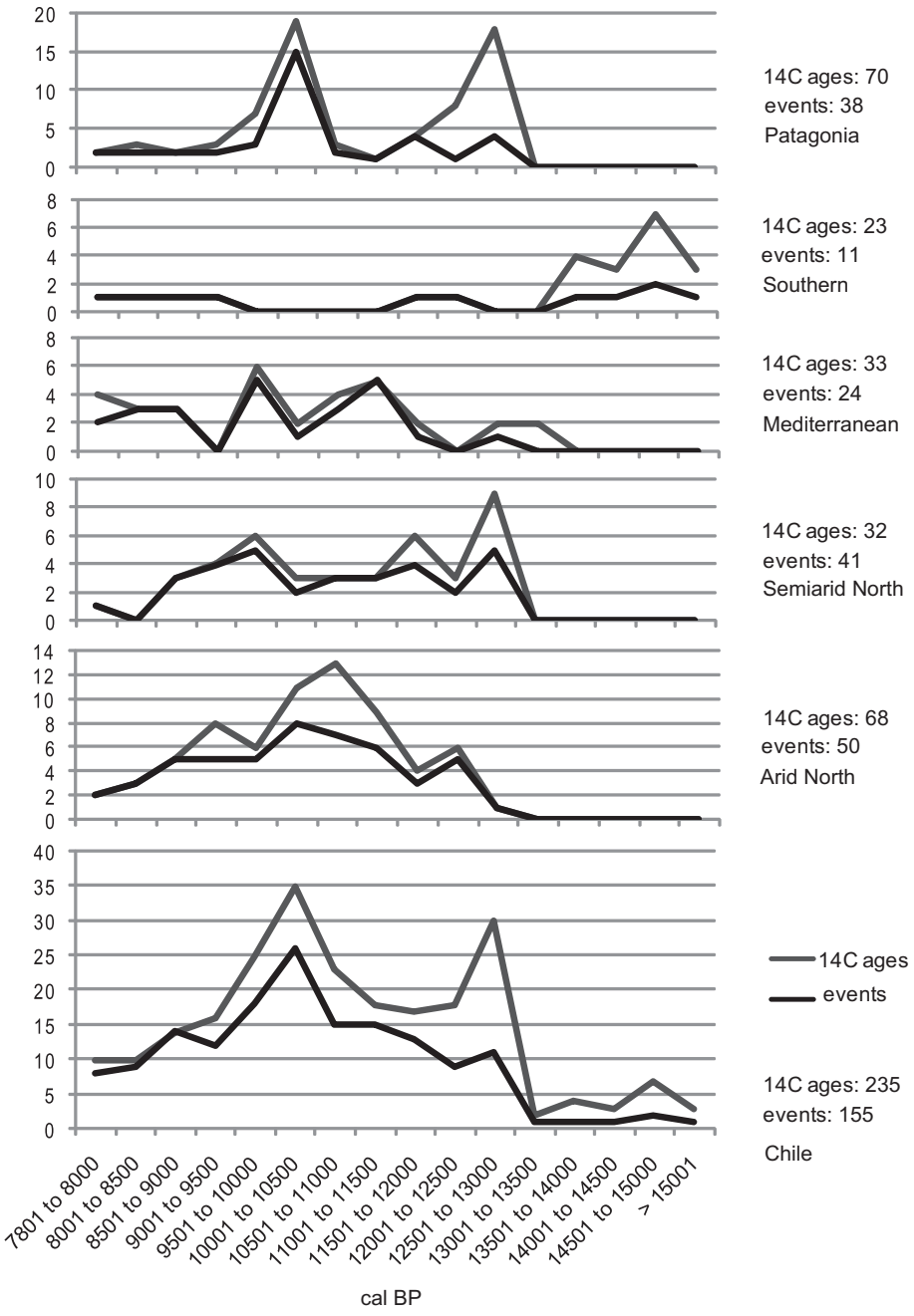

Fig. 2. Calibrated medians of dated samples and occupational events per 500 calibrated year intervals partitioned by region and considering the whole sample.

ages on hearth charcoal yielded an average of 12,710–13,090 cal BP (Jackson et al., 2007). While Quebrada Santa Julia is a short-term lake-edge campsite associated with fluted bifacial reduction activities and where at least one extinct horse (*Equus* sp.) was butchered, Punta Ñagué stands as a coastal-margin residential camp where marine mammals, fish, and shellfish were obtained, processed, and discarded (Jackson et al., 1999). In the case described, the former appears as a terminal Pleistocene human occupation related with inland extinct mammal consumption, while the latter shows the characteristics of early Holocene maritime/coastal-based human adaptations. The Mediterranean zone yields only one occupational event at the Taguatagua 1 site within this interval. At that locality, two excavations uncovered mastodon and *Equus* butchering events at a lake-edge 12,690–13,230 cal BP campsite (Montané, 1968; Núñez et al., 1994). Due to the sigma values of all four available dates, this age should be regarded with caution. Despite yielding the earliest human presence in Chile, the Southern zone has only one date for this interval at the Río Bueno site, where chipping debris and one projectile point were located in association with an 11,990–12,560 cal BP age (Dillehay, 2000). During this interval, most dates (26 ^{14}C ages) have been recorded at Patagonia, however they only account for five occupational events at four sites. While the earliest event was observed at Fell's cave (Bird, 1993), this 12,600–13,210 cal BP age should be regarded cautiously because it yielded large sigma values. However, it should be considered that it remains significantly similar to the earliest occupational event at Cueva del Medio, where a 12,630–13,050 cal BP date was acquired by averaging seven available ^{14}C ages for the site (Nami, 1987; Nami and Nakamura, 1995). These sites, as the other two in the zone, and every other contemporary site in Argentinean Patagonia consist

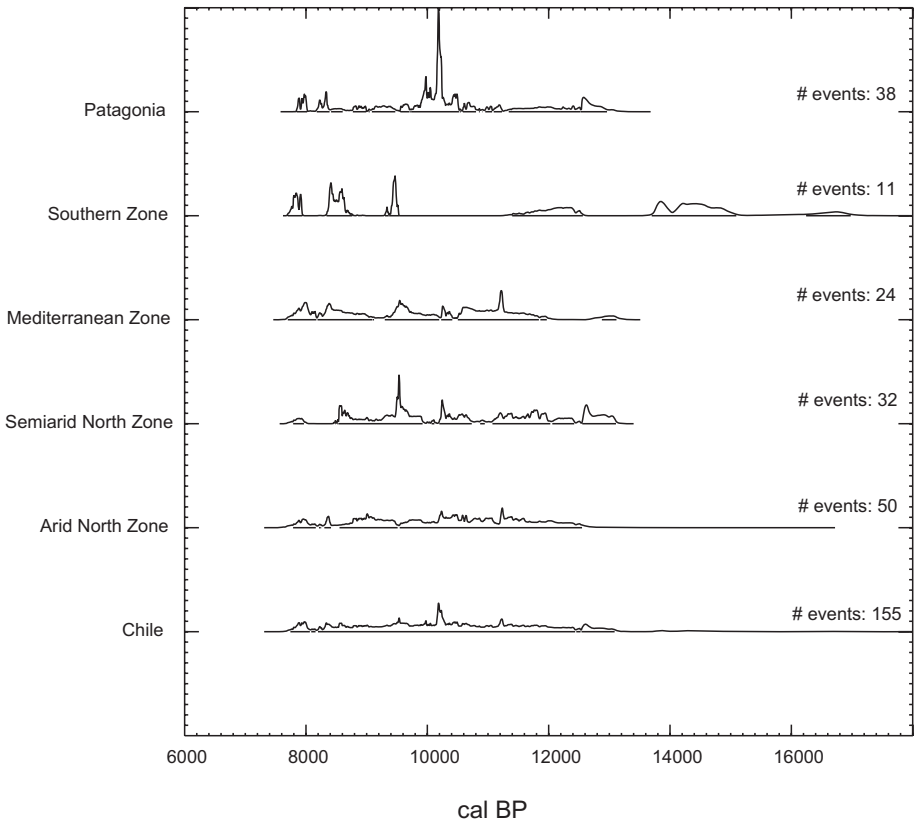

Fig. 3. Summed probability plots for occupational events partitioned by region and considering the whole sample (Calib Rev 6.0.1).

of short-span cave/rockshelter occupations (Borrero and Franco, 1997).

4.2.3. 12,000 to 11,000 cal BP (~10,250 to 9630 BP) interval

Occupations for this interval appear in all regions in Chile, comprising a total of 35 ^{14}C dates from 23 sites, averaging 28 events. Regional distribution of these occupational events is more even than the preceding time span, except for the case of the Southern zone, where only one was identified. Regarding other regions, the Arid North zone yielded nine events (out of 13 ^{14}C ages) at seven sites. In the Semiarid North zone a total of seven events (out of 9 ^{14}C ages) account for the recorded occupations at six sites. The Mediterranean zone yielded six occupational events (out of 7 ^{14}C ages) at four sites within this interval. Patagonia exhibits five occupational events (out of 5 ^{14}C ages), each at one site.

During this interval some regional differences seem to be accentuated. For instance, the Arid and Semiarid North zones (~23° to 32° S) display common archaeological assemblages at open-air coastal sites represented by the Huentelauquén Cultural Complex (Llagostera et al., 2000; Jackson et al., 2011). These include basically shell midden deposits with evidence of subsistence based on fish, shellfish, and pinnipeds, as well as distinguishable stemmed lanceolate projectile points appropriate for sea mammal hunting. In Patagonia, sites such as Cueva del Medio (Nami and Nakamura, 1995), Lago Sofía 1 (Prieto, 1991; Steele and Politis, 2009), Fell's cave (Bird, 1993), and Tres Arroyos 1 (Massone, 2004) showing distinctive fishtail projectile point assemblages, yielded occupational events during the preceding interval and repeat themselves, suggesting spatial redundancy in some caves as a selective choice for settlement. Another particular feature for this chronological interval is the appearance of the earliest directly dated human remains at the sites of Los Rieles in the Semiarid North zone (Jackson et al., in press) and La Patagüilla in the Mediterranean zone (Tagle et al., 2008). Finally, it is precisely during this interval that most widespread climate changes are recorded at each zone, which broadly correlate to the disappearance of most megamammal taxa at archaeological sites.

4.2.4. 11,000 to 10,000 cal BP (~9630 to 8950 BP) interval

Occupational events during this 1000-calibrated year interval appear at four of the five analyzed regions, because no dates have been recorded for the Southern zone. From a total of 58 ^{14}C dates obtained at 21 sites, 41 occupational events were averaged. The Arid North zone yielded 15 events (out of 24 ^{14}C ages) recorded at 12 sites. In the Semiarid North zone a total of five events (out of 6 ^{14}C ages) have been identified at three sites. The Mediterranean zone yields four events (out of 6 ^{14}C ages) at three sites. The majority of events recorded at Patagonia date to this interval, where a total of 17 were averaged (22 ^{14}C ages) only at three sites, which requires some explanation. Baño Nuevo 1 is a cave with redundant human occupations starting at 10,710–11,070 cal BP, where remains of ten individuals have been excavated (Mena and Stafford, 2006). Eight direct dates on bones of seven of the individuals overlap within a 9700–10,200 cal BP range, making them either synchronous, or deposited during an indistinguishable radiocarbon time-span (Reyes et al., in press). Given that direct dates on bones of separate individuals were considered as independent occupation events due to the contextual significance of directly dates early human remains, this exceptional assemblage raises the chronological signal for Patagonia during this interval (Fig. 3). Averaging this dates will result in a smoother zonal plot.

4.2.5. 10,000 to 9000 cal BP (~8950 to 8100 BP) interval

During this time interval, a total of 30 occupational events were averaged from 41 ^{14}C dates obtained at 27 sites distributed at all regions in Chile. The Arid North zone yielded ten events (out of 14

^{14}C ages), recorded at nine sites. The Semiarid North zone shows nine events (out of 10 ^{14}C ages) which have been identified at eight sites. In the Mediterranean zone, five events (out of 6 ^{14}C ages) were observed at five sites. In the Southern zone only one event (out of 1 ^{14}C age) was identified. Patagonia yielded five occupational events recorded at four sites (out of 10 ^{14}C ages). The increasing general trend of dates and occupational events shown until the last interval ceased and started retreating.

4.2.6. 9000 to 8000 cal BP (~8100 to 7250 BP) interval

Results for this interval show 24 ^{14}C dates obtained at 18 sites comprising 23 occupational events recorded at all regions. The Arid North zone yielded eight events (out of 8 ^{14}C ages) recorded at eight sites. In the Semiarid North zone a total of three events (out of 3 ^{14}C ages) have been identified at three sites. The Mediterranean zone yields six events (out of 6 ^{14}C ages) at three sites. The Southern zone has two events (out of 2 ^{14}C ages), each recorded at one site. In Patagonia, four events (out of 5 ^{14}C ages) were recorded at three sites. This general analysis shows an overall decline in the amount of dated archaeological contexts in Chile and an accentuation of the general trend starting ~10,000 cal BP. This trend is best viewed in the two regions with most dates/events (Arid North zone and Patagonia) and in the general cumulative data for all of Chile (Fig. 2).

The abrupt end of the record is an artifact of the dataset and represents the 7000 BP arbitrary limit. From the end of the last interval to 7800 cal BP (200-calibrated year interval), eight occupational events (out of 10 ^{14}C ages) were recorded at seven sites distributed in all regions in Chile.

4.3. Site characteristics and associations

Characteristics of archaeological sites between ~15,600 and 7700 cal BP vary greatly depending on regional and environmental differences, thus comparisons would rely only on general attributes in order to be broad enough to compare data. Type of sites, distance to the current seashore, and faunal remains associated with the occupational events were selected as means to approach general trends related with the environmental settlement choices.

Regarding site types, the great majority of occupational events for the period in discussion were recorded at caves or rockshelters (49.68%; Table 3). This value is significantly influenced by the research in Patagonia, where all early occupations have been recurrently identified at such localities, most probably due to research biases (Borrero and Franco, 1997). Considering those biases, Jackson (2007) suggested that the structural attributes of caves provided both shelter against harsh weather conditions and constraint for the spatial organization of activities, thus constituted selective choices for early inhabitants in southernmost Patagonia. Occupations at open-air coastal sites are only frequent in the Arid North and Semiarid North zones, in particular at the southernmost area of the latter (~31°50′–32 S), where the area around Los Vilos town has been subjected to an intensive local research program (Jackson and Méndez, 2005). This <100 km^2 littoral strip yielded 15 of the 19 sites for this period in the Semiarid North zone and accounts for 46.15% of the coastal occupational events identified at all Chile. Open-air inland dates are scarcer: however, they stand out in the Mediterranean zone, where several sites in the Taguatagua basin (Montané, 1968; Kaltwasser et al., 1983; Núñez et al., 1994) show a distinct lake-shore orientation from the terminal Pleistocene through the early Holocene.

Distance to the current coastal margin was considered as means to establish the role of littoral environments and their resources as potential areas selected for settlement. Distances were measured in a direct west-to-east line from the site to the Pacific shore. Although this is a appropriate measure for most sites north of 42° S, the coast of archipelagic Western Patagonia offers a higher degree of complexity (Fig. 1), as the shorter distance is not necessarily the former. Nevertheless, this last area has the lowest occurrence of coastal sites with early occupations and was covered by ice caps during part of the period in question. Although measuring the distance to the coastal margin may be considered problematic in view of the Post-Glacial sea-level rise, the significant steepness of the continental shelf in large areas of Chile limited the amount of land inundation, thus minimizing the possible bias of this measure. This is especially true for northern Chile (Richardson, 1981) and has been calculated for the coastal areas surrounding Quebrada Santa Julia (Jackson et al., 2007) and Monte Verde (Dillehay et al., 2008), where no significant differences appear as result of sea-shore shifting position during the time of site occupation. An exception is the littoral area between ~36°30′–38°50′S, where the lack of coastal sites earlier than 6730–6400 cal BP has been alternatively explained as due to the post-Glacial sea level rise (Quiroz and Sánchez, 2004).

Distances to the current coastal margin were available or measured for 77 of the 81 sites discussed here. These account for 150 occupational events and are presented in 50-km intervals in Fig. 4, with greater detail for the first 50 km. The measured distances differ greatly between regions and within each region. The highest number of coastal occupational events (≤10 km) was recorded at the Semiarid North zone, closely followed by the Arid North zone. However, the latter exhibits a significant frequency of occupational events at sites further than 150 km from the coast, especially at 24°S which coincides with the widest segment of Chile (Fig. 1). This situation is a strong reflection of the hunter-gatherer archaeological record in the Arid North zone, which is generally frequent in the coast and at high altitude locations where preferred foraging and hunting resources abound, while being significantly scarce in the mid Atacama Desert. These two zones yield defendable recurrent coastal occupations for the period in question, whereas south of 32°S sites further than 50 km from the coastal margins seem as distinctively selected. Particularly, the coastal evidence in southwestern Patagonia is suggestive of maritime oriented settlements starting at the mid Holocene (Legoupil and Fontugne, 1997).

Table 3
Number of occupational events associated with general type-sites per region.

Region	Cave/rockshelter	Open-air		No data	Total
		Inland	Coast		
Arid North zone	25 (16.13%)	5 (3.23%)	18 (11.61%)	2 (1.29%)	50 (32.26%)
Semiarid North zone	2 (1.29%)	3 (1.94%)	27 (17.42%)	–	32 (20.65%)
Mediterranean zone	8 (5.16%)	10 (6.45%)	6 (3.87%)	–	24 (15.48%)
Southern zone	4 (2.58%)	7 (4.52%)	–	–	11 (7.1%)
Patagonia	37 (23.87%)	–	1 (0.65%)	–	38 (24.52%)
Total	77 (49.68%)	25 (16.13%)	52 (33.55%)	2 (1.29%)	155 (100.00%)

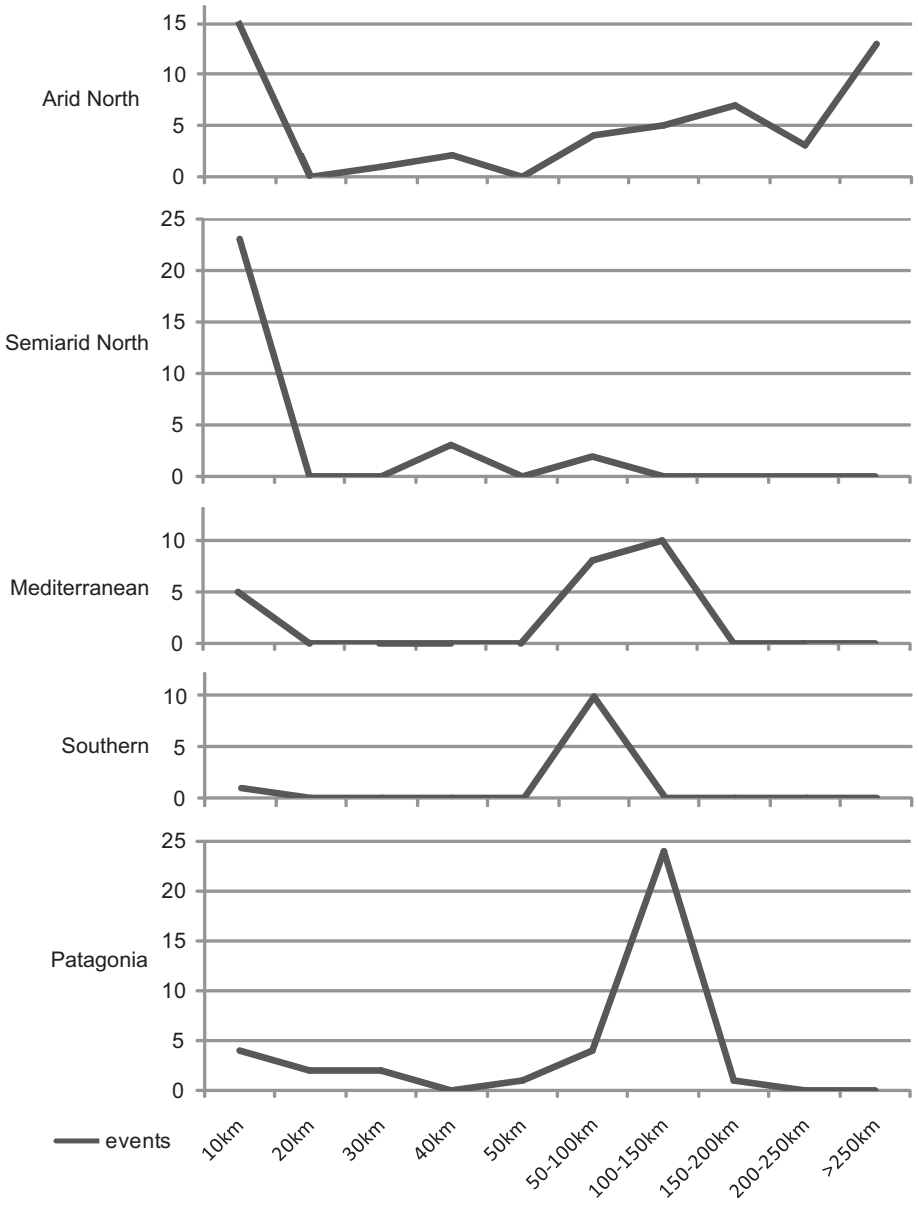

Fig. 4. Frequency of occupational events in relation to the distance from the current coastal margin partitioned by region with greater detail for the first distance intervals.

Faunal assemblages vary greatly within the occupations and sites sampled. General types of faunal assemblages were discriminated according to habitat characteristics and to whether or not they corresponded to extinct faunas (Table 4). These data were further partitioned into two chronological groups at 11,500 cal BP (10,000 BP) as an arbitrary limit between the Pleistocene and the Holocene. Data show a great variety of assemblages, with a highest representation of occupations only yielding modern terrestrial fauna, typical of inland early Holocene occupations, and occupations with modern terrestrial, coastal and marine faunas, characteristic of littoral broad-spectrum early Holocene assemblages. As expected, extinct faunas were mainly recorded at occupational events older than ~11,500 cal BP and particularly in Patagonia. Here, however, they appear always in association with modern taxa, thus suggesting subsistence choices based on prey such as guanaco (*Lama guanicoe*) and to a lesser extent in extinct megamammals (Borrero and Franco, 1997). Data also show extinct faunas are significantly underrepresented at occupations in the Arid North zone. However, the most insightful comparison can be observed considering occupational events associated with the presence of extinct faunas in their assemblages in a temporal basis (Fig. 5). While extinct faunas peak in the 12,501–13,000 cal BP interval, modern faunas peak in the 10,001–10,500 cal BP interval. Evidence, though usually not directly dated, shows extinct faunas at archaeological sites ceasing at the onset of the Holocene and seldom represented ever since. These data should be carefully considered, because: (1) it does not distinguish regional differences, (2) there are few in-depth taphonomic evaluations for the all archaeological contexts, and (3) it is not based on taxon-dates. The ^{14}C averaged occupational events with extinct faunas later than 11,500 cal BP were recorded at Tuina 5 (11,260–11,750 cal BP; Núñez et al., 2002), Taguatagua 2 (11,230–11,800 cal BP; Núñez et al., 1994), Cueva del Medio (10,800–11,250 cal BP; Nami and Nakamura, 1995), Fell's cave (9710–10,500 cal BP; Bird, 1993), and Pali Ake (8540–10,790 cal BP; Bird, 1951).

Table 4
Number of occupational events associated with types of faunal assemblages.

Zones	Arid North zone	Semiarid North zone	Mediterranean zone	Southern zone	Patagonia	Total
11,500–7700 cal BP						
Extinct fauna	–	–	1 (0.65%)	–	–	1 (0.65%)
Extinct & modern fauna[a]	1 (0.65%)	–	–	–	3 (1.94%)	4 (2.58%)
Modern terrestrial fauna	18 (11.61%)	1 (0.65%)	4 (2.58%)	3 (1.94%)	22 (14.19%)	48 (30.97%)
Modern terrestrial & Coastal/marine fauna	14 (9.03%)	13 (8.39%)	6 (3.87%)	–	–	33 (21.29%)
Coastal/marine fauna	–	7 (4.52%)	6 (3.87%)	–	–	13 (8.39%)
Fresh-water fauna	–	–	3 (1.94%)	–	–	3 (1.94%)
No fauna	3 (1.94%)	–	–	–	3 (1.94%)	6 (3.87%)
>11,500 cal BP						
Extinct fauna	–	2 (1.29%)	1 (0.65%)	1 (0.65%)	–	4 (2.58%)
Extinct & modern fauna[a]	–	–	–	4 (2.58%)	8 (5.16%)	12 (7.74%)
Modern terrestrial fauna	3 (1.94%)	2 (1.29%)	–	1 (0.65%)	–	6 (3.87%)
Modern terrestrial & coastal/marine fauna	4 (2.58%)	6 (3.87%)	1 (0.65%)	–	–	11 (7.1%)
Coastal/marine fauna	–	1 (0.65%)	–	–	–	1 (0.65%)
No fauna	–	–	–	1 (0.65%)	1 (0.65%)	2 (1.29%)
No available data	7 (4.52%)	–	2 (1.29%)	1 (0.65%)	1 (0.65%)	11 (7.1%)
Total	50 (32.26%)	32 (20.65%)	24 (15.48%)	11 (7.1%)	38 (24.52%)	155 (100.00%)

[a] Includes terrestrial, coastal, and marine faunas.

Direct ages of specific genera or species from the archaeological sites for the period in discussion are only available for the following taxa: *Cuvieronius* ($N=2$), *Ducisyon avus* ($N=1$), Equidae ($N=3$), *Hippidion* sp. ($N=2$), *Hippidion saldiasi* ($N=4$), *Lama* sp. ($N=1$), *Lama* cf. *Owenii* ($N=3$), *Lama guanicoe* ($N=5$), Macrauchenia ($N=1$), *Mylodon* sp. ($N=6$), *Mylodon darwini* ($N=1$), *Palaeolama* sp. ($N=1$), *Pantera onca messembrina* ($N=1$), *Pseudalopex culpaeus* ($N=1$), and *Vicugna* sp. ($N=1$). These ^{14}C dates were recorded in the Semiarid North, Southern and Patagonia zones, although largely concentrated in the latter (84.85%). This reflects a singular interest in measuring the extinction rates among the research projects in the area of Última Esperanza (Borrero, 1997). Human association with extinct fauna bones by means of taxon-dates is defendable in 17 cases (51.52%), 16 of which were recorded also in Patagonia.

5. Discussion

Establishing the timing of the initial settlement of a region and the changes in chronological trends can be better understood by considering series of dates averaged in minimal number of occupational events in a subregional basis. This analysis may help isolating biases such as differential research intensities which could eventually lead to misguided interpretations. Fig. 2 shows the frequency of ^{14}C ages/occupational events discussed per 500-year intervals partitioned by ecological zones. Fig. 3 shows general and zonal summed probability plots, which should be regarded as provisional due to the small amount of dates used, especially because plots based on less than 200–500 ^{14}C ages are likely to change once larger datasets are considered (Williams, 2011). However they may have at least two conditional uses: (1) to aid in broad regional comparisons, and (2) to serve in planning sampling strategies for solving key chronological issues.

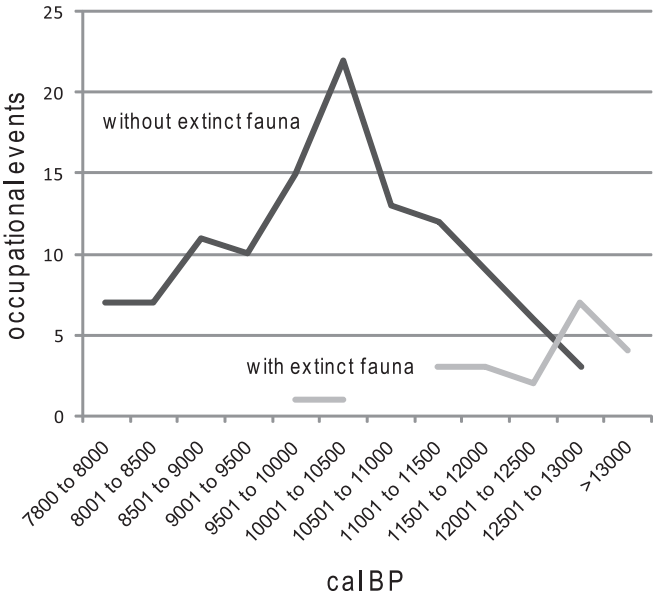

Fig. 5. Frequency of occupational events in relation to the presence of extinct faunal remains within dated archaeological deposits per 500 calibrated year intervals.

5.1. Initial human presence in Chile: discussing occupational events in a regional basis

Regions with low frequency of early dates, such as the Southern zone, are difficult to evaluate. While part of the littoral evidence may be submerged, the paucity of human occupations in this area as a whole during the period in question appears as research-oriented. Archaeological studies have recurrently privileged understanding "late" human presence through the study of sites with ceramic assemblages throughout this zone. Nonetheless, Monte Verde II marks the initial human presence detected in the country as a whole and in the Southern zone in particular at the 14,501–15,000 cal BP interval through a series of dates within the same archaeological deposit (Dillehay and Pino, 1997). However, these data are chronologically isolated since the subsequent dates are 11,990–12,560 cal BP at Río Bueno (Dillehay, 2000) and 11,390–12,230 cal BP in the basal occupation of Marifilo 1 site (Mera and García, 2004), showing at least a ~2000-calibrated year separation. This last occupation is again separated by ~2500 calibrated years from the next date within the same stratum (Mera and García, 2004). Currently, it seems complicated to relate Monte Verde II with the archaeological record at later sites within the local region, thus limiting the support on persistent hunter-gatherer occupations thereafter.

In addition to the research biases mentioned, the visibility issue must be considered among the crucial factors affecting this intermittent trend. The primary feature precluding visibility is vegetation coverage, which also limits erosion, thus constituting a chief factor inhibiting site identification. Broadly, this can be exemplified by the greater frequency of pre-7700 cal BP occupations in the Arid

and Semiarid North zones, as opposed to Mediterranean and Southern zones. This agrees also with data from Patagonia, where almost all pre-7700 cal BP have been recorded at semiarid locations of steppe vegetation or within the steppe/forest transition east of the Andean mountain range, and not within the evergreen forest.

Besides the area between 35°50′–39°30′S, other specific segments lacking occupations earlier than 7700 cal BP are located between 26°40′–29°30′S, 42°–44°S, and 47°10′–51°30′S. These areas should be the focus of future research in order to establish if the observed trends reflect past population distributions or solely research biases. However, the lack of research projects in these specific areas supports the latter. For the rest of Chile, despite the current need for more archaeological work on early sites and oriented-sampling, the available data are appropriate for an initial assessment of the timing of early peopling in the region.

For regions other than the Southern zone, chronological trends show a consistent human presence starting at the 12,501–13,000 cal BP interval (Fig. 2), or immediately after 13,000 cal BP, with a slightly later signal in the Arid North zone (Fig. 3). However, the neighbor area of Southern Perú (Sandweiss et al., 1998; Rademaker et al., 2013) has yielded consistent terminal Pleistocene human evidence, thus supporting the general temporal marker mentioned above. After the initial human signal, a series of higher-than-average density ^{14}C events can be observed at the summed probability plot for Chile. Six peaks with different intensities are shown, of which the one located at ~10,200 cal BP is the most significant, agreeing with the highest frequency of occupational events recorded for 500-calibrated year interval ($N = 26$). It is still very early to suggest if any of these peaks is related to hunter-gatherer population increases, especially due to potential research biases, among them the low frequency of averaged occupational events. However, at least the highest peak is also reflected in four of the zonal plots, thus covering a significantly large and ecologically differentiated area, therefore lending support for a demographic interpretation of the data.

The chronological signals vary considerably between regions and have limited significance due to the low frequency of occupational events when divided by zone. The Arid North zonal plot shows the highest similarity with that of Chile as a whole, because it contributes with the largest number of data, strongly influencing the summed result. Some other observations can be considered. Similarities in chronological signals between Semiarid North and Mediterranean zones between ~10,400 and 9000 cal BP are noticeable, both in their peaks and troughs. Future assessments should consider verifying if these trends have archaeological significance (e.g. human regional responses to climate change). Also, the plot most divergent from the whole set is the one from Patagonia. This is probably due to the fact that southernmost South America was probably peopled following exploratory routes along the Atlantic slope (Borrero and Franco, 1997). This is reflected by the fact that the earliest sites at Argentinean Patagonia and in Chile at latitudes higher than 51° S show an earlier initial human presence than those located between 44°–48° S in the Aisén region (Méndez et al., 2009). The latter could constitute a marginal area, more influenced by glacial activity, and only peopled from eastern settlement nodes established earlier (Borrero, 2004). Another factor affecting the differences between Patagonia and the general data in Chile is related with the high chronological signal associated with the recurrent burials at Baño Nuevo 1 site between 9700–10,200 cal BP (Mena and Stafford, 2006; Reyes et al., in press). In this case, dates appear as an appropriate measure for assessing quantitatively the intensity of the human regional signal.

The decrease in chronological signal after 8000 cal BP at all summed probability plots and in the frequency of dates in the 7800–8000 cal BP interval are artifact of the dataset, and should not be considered representative of peopling dynamics. However, it is interesting to consider that both the general summed probability plot and the zonal plots show similar significant drops on occupational events around 8000–8250 cal BP. At least in the Arid North zone, significantly arid conditions during the mid Holocene have been identified as a trigger for a settlement pattern reorganization (Grosjean et al., 2007), thus probably acting over the ^{14}C distributions. However, such climate patterns and human responses should not be extrapolated for the rest of Chile. Despite the interest of this archaeological problem, changes in human dynamics during the mid Holocene are beyond the scope of this paper.

5.2. Coexistence/interaction of extinct faunas and human beings

The first evidence for late Pleistocene human presence in Chile was located in Fell's cave, and consisted of bones of native horse, *Mylodon*, and paleocamelids in direct association with hearths (Bird, 1993). Ever since, the quest for early human occupations (as in most of the continent) has been biased in favor of the evidence of human-extinct fauna interactions. While this kind of evidence has been identified at several locations south of the 31° S (Dillehay, 1989, 1997; Jackson et al., 2004; Borrero, 2009), it has been largely absent in the Arid North zone. This paucity was interpreted as a cultural trait, thus labeling early assemblages as Archaic Period characterized by hunting practices of modern prey (Santoro, 1989). The only extinct fauna remains in the Arid North zone are those excavated at Tuina 5 (Núñez et al., 2002), and have been discussed either as a reflection of latest Pleistocene environments devoid of megamammal taxa or as a selective preferences (Jackson et al., 2004).

In general, extinct faunal remains in archaeological sites have been thoroughly studied (taxonomy, taphonomy, economic indicators, technology). However, human–extinct fauna interactions should not be exclusively assessed through archaeofaunal analyses; but encompassed with a systematic gathering of chronological data in order to establish coexistence with human beings and extinction rates by means of taxon-dates. Only then, prey choices will be appropriately evaluated. Currently there is insufficient data for such purpose, both in archaeological and paleontological sites (Barnosky and Lindsey, 2010). The only exception could be that of Última Esperanza, where there is no evidence of megafaunal Holocene survival (Borrero, 2009), and though coexistence with humans is defendable, extinction appears as climate-driven (Cárdenas et al., 2005). For the rest of Chile, the number of taxon-dates on extinct fauna still remains small for evaluating the interaction with human beings.

5.3. Early coastal human occupations

One of the most straightforward analyses in view of the debated early coastal migratory route hypotheses (Fladmark, 1979; Dixon, 1999) in a region dominated by an extensive littoral area is to evaluate the chronological signal of human occupations at coastal archaeological contexts. In this paper site distance to the coastal margin and archaeofaunal records were measures for assessing the degree of selectivity of littoral environments by human groups during the period in discussion. Recurrent archaeological records in proximity of the coastal margin (<50 km) could only be defended in the case of the Arid and Semiarid North zones. Thirty-two occupational events (Arid North zone: 9; Semiarid North zone: 23), mostly at open-air sites, are characterized by distinctive coastal settlement patterns, lanceolate stemmed projectile points suitable for sea-mammal hunting, and archaeofaunal assemblages yielding marine mollusc shells, fish and pinnipeds. These sites extend from 23°30′ to 32° and have been attributed to the Huentelauquén Cultural Complex (Llagostera, 1979; Llagostera et al., 2000; Jackson et al., 2011). A selection of dates not subject to reservoir effect can

confidently position these occupations between ~11,800 to 8500 cal BP. This temporal range is 1200 calibrated years younger than the initial human presence recorded for the zones comprising these sites.

In the scenario described above, a consistent early coastal human presence is defendable only for the two abovementioned zones, where besides the significant number of early Holocene dated occupational events near the coastal margin, a distinctive littoral economy characterizes the archaeological record. Most sites have been related with a single archaeological cultural complex, with attributes other than formal tool types as common traits linking the evidence. These data are in consistency with evidence in the broader region of the Pacific coast of South America where similar chronological and broad spectrum subsistence strategies have been recorded at sites in Ecuador and Perú (Sandweiss et al., 1998; de France et al., 2001; Sandweiss, 2008). Recently, new attractive evidence of seaweed consumption in the Monte Verde II site has come to light (Dillehay et al., 2008). These data have been interpreted as supportive of the idea of an early settlement of South America along the Pacific coast. However, data on Monte Verde II should be considered cautiously because it is isolated, both temporal and spatially, from the rest of the coastal evidence discussed here.

6. Conclusions

This paper has raised a wide variety of chronological problems which need to be addressed. Among them are the need for a more widespread use of ^{14}C AMS technique, therefore increasing dating precision, improving the quality in reporting dates and associated information, working on solving the marine reservoir effect on a local and regional basis, and focusing on date repeatability within archaeological deposits. Another lingering issue is the lack of taxon-dates in order to assess human/extinct fauna coexistence and regional extinction rates. Probably the most concerning topic limiting the understanding of early chronological trends in Chile is the uneven nature of the regional sampling. Only small parts of the whole territory currently yield most of the ^{14}C data, and several questions raised in this paper could solely be answered by studying the areas yet devoid of such information.

Nonetheless, the results described in this paper support the idea of a consistent regional peopling of Chile right after 13,000 cal BP. This is indicative of demographically viable hunter-gatherer groups occupying most regions. However solid, earlier evidence still needs of other chronological data in order to be able to link with the rest of the evidence summarized here. While research biases product of the differences in regional sampling should be considered among the main factors affecting this chronological issue, two other possible non-mutually exclusive alternatives must be considered. Either the archaeological signal earlier than 13,000 cal BP is minimal and has not yet been identified elsewhere than in the Monte Verde/Chinchihuapi area, or Monte Verde II represents an unsuccessful colonizing event, which could be in agreement with the intermittence in the chronological signal described for the Southern zone. In either case, the need for further research and new evidence is essential.

However complex, data summarized in this paper support the idea of a diversified scenario for the early peopling of the region. No single tool-type, prey choice or settlement type can be traced as a common or unique feature for characterizing the earliest peopling of the country as a whole. Regional approaches where sites can be related to one another through common material traits, raw-material flows, and/or similar resource choices should be associated within confident time frames in order to draw reliable peopling models. This diversity is probably related with the use of more than one route during the initial dispersion, either inland, coastal, or both and possibly occurring within different times frames, as shown by the zonal differences observed. In this sense, an interesting case can be suggested, considering the modeling nature of the Andean mountain range. Chile, north of Patagonia can be understood as a biogeographical corridor running along the Pacific slope, while south of 42°S all early evidence is located east of the Andes and linked with the Atlantic slope. As in other archaeological cases (Méndez and Reyes, 2008), the Andean mountain range acted as an effective natural barrier modeling long-term human adaptations, which would have been especially acute in a post-Glacial changing environment. Population dynamics at Arid North through Southern zones should be understood in conjunction with that of other coastal and inland areas along the western slope of the Andes including, Perú and Ecuador. On the other hand, evidence in Chilean Patagonia shares several similarities with the Argentinean Pampa and Patagonia regions, and thus need to be discussed within that macro-region. Chronological trends may be a powerful tool for analyzing population dispersals and long-term responses to climate fluctuations, considering the impact such barriers may have had during the initial peopling of a region.

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Appendix A. Supplementary material

Supplementary data related to this article can be found online at doi:10.1016/j.quaint.2012.04.003.

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