Habitats of ancient hunter-gatherers in the Puna: Resilience and discontinuities during the Holocene

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ABSTRACT

Hunting groups are closely linked to the environments in which they live, especially in the deserts. This paper explores the relationship between people and desert environments in the long term using key concepts such as resilience, refugia and habitat loss. A thorough paleoenvironmental analysis was conducted to improve our understanding about continuities and discontinuities in the archaeological record of the South Andean highlands. This allowed us to test ideas about the availability of adequate human habitats during the Holocene. Cultural archives such as archaeofauna and lithic technology are employed to illustrate and discuss methodological perspectives for the identification and description of resilient human habitats in arid landscapes in the South Andean Puna.

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1. Introduction

Deserts are characterized by their high aridity, heat, and salinity; organisms that inhabit a desert environment must be adapted to these factors. The main hazard that the desert biota must overcome is the low precipitation volume, as well as its significant temporal and spatial variation. To our purposes, hazard refers to climate-related physical events or trends or their physical impacts (IPCC, 2014). The ability of a social system to cope with hazardous events or trends is essential for the long-term survival and reproduction of human populations. The capacity of social and environmental systems for coping with disturbance events or tendencies while maintaining or reorganizing their basic function and structure can be defined as resilience (IPCC, 2014). In the case of human and animal populations, resilience is related to the capacity of adjustment to the current or expected climate and its effects.

When the trend of change is slow, adaptation becomes "embedded in some planning process" (IPCC, 2014:8). In the case of hunter-gatherers, this means adjustments in mobility, social organization, development of new technological options, and change in the use of resources (Bar Yosef, 2014; Binford, 2001; Sandweiss, 2014). This situation could be accentuated when a human popula-

tion faces climate extremes, such as persistent droughts. Social mechanisms, such as those already mentioned, can be put in motion in order to mitigate the impact of the abrupt climate changes for sustaining adaptation capacity. The scales of these changes must be carefully evaluated, but they undoubtedly affected the demographic patterns and other social structures of past hunter-gatherers (Burroughs, 2005).

In this paper we explore several concepts borrowed from Ecology -resilience, habitat loss and refugia- as theoretical tools to improve our understanding about continuities and discontinuities in the archaeological record of the South Andean highlands. We summarize the paleoenvironmental history of the Holocene in the Dry Puna region, testing ideas about the availability of habitats suitable for humans throughout the period. We use two archaeological data sets -archaeofauna and lithic technology- to illustrate and discuss methodological perspectives useful to identify and describe resilient human habitats in the arid landscape of the Andean Puna. In this paper discontinuity does not refer to an interruption of the archaeological record in time or space only; it also includes the innovations and/or changes in human strategies in order to cope with climate change.

2. The Puna environment today

The Puna of Argentina and Chile comprises the arid highlands between 19° and 27°S latitude and between 3000 and 4500 m asl. This area is defined as a Highland Desert Biome dissected by

several mountain ranges oriented NE-SW. It is characterized by high solar radiation due to it altitude, a significant diurnal thermal variation, a marked seasonality in rainfall, and low atmospheric pressure. Primary productivity is concentrated in stable hydrological systems, such as primary basins, high gorges, and wetlands. A small number of permanent freshwater basins, salt lakes, pans and playas constitute the general hydrological network. A few rivers and several springs scattered in the landscape are the only sources of freshwater, which is a critical resource for human populations. The summertime rainfall in the region is largely governed by the so-called South American Monsoon-like System (Zhou and Lau, 1998). This system produces about 80% of annual precipitation volumes, which occurs in the Andean highlands between December and February (Vuille and Keimig, 2004). In turn, these conditions determine a heterogeneous distribution of vegetal and animal resources, where a few localized patches contain most of the available regional biomass.

The Puna of Argentina exhibits a latitudinal gradient in aridity that allows the identification of two sub-regions: (1) the Dry Puna, north of 24°S, with a mean annual precipitation of 340 mm/yr (reaching even 400–500 mm/yr in some localities of the northern-western sector), and (2) the Salt Puna, south of 24°S, in which precipitation barely reaches an average of 100 mm/yr. Salt-lakes and saline soils are dominant features of this landscape (Morales, 2011).

Along with altitude variation, the factors described above are responsible for the variability in plant assemblages, ranging from 'tolar' (shrub steppe) to 'pajonal' communities (herbaceous grasslands), with scattered 'vegas' (wetlands) located in both of these vegetal communities. Four main plant communities can be identified in the Puna (Cabrera, 1976; Arzamendia et al., 2006; Borgnia et al., 2010):

1. Shrub steppe (*tolar*): dominated by *Parastrephia lepidophylla* and *Fabiana densa* with a low proportion of herbs (5%). This is the most extensive pasture area of the region and it is located between 3500 and 3900 m asl.
2. Herbaceous steppe (*pajonal*): dominated by *Festuca* spp. and other grasses, like *Poa* spp. and *Stipa* spp., can be found between 4100 and 4700 m asl. Above 4300 m asl, shrub presence is reduced almost completely.
3. Wetlands (*vegas*): restricted swamp areas composed of short grasses. These dense grasslands of Deyeuxia spp. and Mulembergia spp. are distributed in both altitudinal settings, ranging from 3500 to 4700 m asl (Ruthsatz and Movia, 1975).
4. Mixed steppes: assemblages of Gramineae and Compositae (only eight genera are present) found between 3900/4100 m asl.

3. Paleoenvironmental conditions

Past environmental conditions in the South-central Andes since the Last Glacial Maximum have been extensively studied in the past two decades. The information obtained has shown a complex and heterogeneous picture regarding the different effects of climate on the Holocene Andean landscapes on several spatial scales (i.e. ranging from continental to local).

The initial human dispersal in the highlands of northwestern Argentina and northern Chile seems to have occurred in very cold and humid conditions (Yacobaccio and Morales, 2013) which fostered the downslope advancement of the herbaceous steppe between 700 and 1300 m below the current altitude (Fernandez et al., 1991) and a flood stage in the lakes of the region (Sylvestre et al., 1999; Geyh et al., 1999; Baker et al., 2001; Bradbury et al., 2001; Abbott et al., 2003). Initial human dispersal seems to have

started after the Tauca III phase, in the final part of the Ticaña "dry" (and probably warm) event *ca.* 11,000 BP (13.300 cal BP).

Definitive occupation of the area seems to have been established during the Early Holocene (Yacobaccio and Morales, 2013), in the humid Coipasa event that started *ca.* 9500 BP (11.045 cal BP) (Sylvestre et al., 1999). The environmental conditions during the Early Holocene (10.000–8000 BP [11.475–8800 cal BP]) in the Andes were more humid, and the landscape was more homogeneous than today (Thompson et al., 1995, 1998, 2006; Bradbury et al., 2001; Ramirez et al., 2003). The Early Holocene also presented a weaker seasonality in rainfall and a low to moderate frequency in short term climate variability (see review in Morales, 2011). The ecological impact of these changes in the amount of moisture and its spatial and temporal distribution triggered significant environmental modifications. For instance, in periods such as the final Pleistocene, moisture availability allowed the maintenance of the herbaceous steppe in lower altitudes, thus replacing the current shrub steppe (Markgraf, 1985; Oxman, 2015; Tchilinguirian et al., 2014). Also, the regional abundance of pack rat middens (Latorre et al., 2003, 2006) and paleosoils (Morales, 2011, see below) clearly suggest more humid and stable conditions during the 10.000–8000 BP (11.475–8800 cal BP) time-span. The end of these environmental characteristics occurred non-synchronously, being somewhat later (at least *ca.* 7000 BP [7774 cal BP]) in the South Central Andean region (Northern Chile and NW Argentina). This late chronology is mainly evidenced in water bodies with broad moisture catchment areas, especially those located above 4000 m asl (Morales, 2011).

Although the stable, humid and probably cooler conditions that characterize the Early Holocene are well accepted by scholars, the complexity of Middle Holocene paleoenvironmental signals has led to a heated debate about the nature of the regional climate during this period in the Puna de Atacama (Grosjean, 2001; Grosjean et al., 2003; Latorre et al., 2003, 2006). Some of us have recently put forth our position on this topic, proposing a general trend towards aridization that fostered a hydrologic stress process in the Tropical Andes that is traceable along the Mid-Holocene (Tchilinguirian and Morales, 2013). During this time-period (8000–4000/3500 BP [8800–4390/3730 cal BP]) the climate seems to have been warmer and arid, with a marked seasonality in rainfall. The period also presented intense and frequent short-term climate variability. Mid-Holocene records show that several lakes and "*lagunas*" dried out (Geyh et al., 1999; Bradbury et al., 2001); numerous wetlands disappeared and the grassland steppe was displaced upwards, above the 4000 m asl contour. Modifications in the atmospheric circulation system due to the intensification of the South Atlantic Anticyclone (Villagrán, 1993) and changes in the orbital cycle, which modified the insolation levels in the area (Rowe et al., 2002), have been proposed as the main causes for these climate shifts. However, the mid-Holocene was not homogeneous along its 5000 years. At least two different phases could be isolated. The 8000–6000 years BP [8800–6800 cal BP] span, or Mid-Holocene I, was a transitional phase between the moister and colder Early Holocene and the drier, less stable and warmer conditions of the end of the Mid-Holocene. During this transitional period, the high groundwater levels achieved during the Early Holocene allowed the retention of wetland characteristics in several localities until *ca.* 7000 BP (7774 cal BP), as shown by the alluvial sediment deposits in the Bolivian altiplano (Servant and Servant-Vildary, 2003), the peat and palustrine deposits of Quebrada Puripica (Grosjean, 2001) and Quebrada Lapao (Yacobaccio and Morales, 2005; Morales, 2011), and the delay in the transition to drier conditions in wetlands sediments at Pastos Chicos and Laguna Colorada in NW Argentina (Morales, 2011; Tchilinguirian, 2009; Tchilinguirian et al., 2014). In turn, the Mid-Holocene II (6000–4000/3500 BP [6800–4390/3730 cal BP]) was extremely arid in the regional scale.

Locations above 3000 m asl present evidence of a more or less synchronic interruption in moisture input at about 6200 BP (7100 cal BP), and a strong desiccation event around 5000 BP (5740 cal BP). This pattern is clearly compatible with the onset of the first El Niño-type event, recorded around 7000–6000 BP (7774–6800 cal BP) (Villagrán, 1993; Veit, 1996; Riedinger et al., 2002), which produces an increase of moisture in the lowlands and extreme aridity in the highlands and the eastern slope of the Andes. The Mid-Holocene concludes with the onset of the moister and highly variable conditions of the Late Holocene (4000/3500 BP-present day), which coincides grossly with the onset of the current characteristics and periodicity of ENSO (El Niño Southern Oscilation) events.

4. Wetlands history in the Dry Puna

Kelly (1995) has clearly showed that most of the organizational spheres in extractive societies (mobility, group size, etc.) are systematically related to their habitats. As an example, Veth (2005) has stated that mobility plays a central role in minimizing risks in desert areas. In the same way, Kelly (1995) has suggested that hunter-gatherer groups in desert environments may choose to remain in locations where water is readily available, paying the costs with their food return rate, instead of moving to another location of where water availability is uncertain. Thus, key resources such as water and pastures are the structuring elements of hunter-gatherers life ways in desert environments. For this reason, the history of wetlands (lakes, springs, pools, pans, playas, etc.) must be studied in order to effectively model stability and change in organizational patterns and strategies among hunter-gatherers. We also consider a set of concepts that will be extremely useful to properly characterize the role and history of particular habitats through time. These concepts refer to habitat resilience, ecological refugia and habitat loss.

In Ecology, resilience is the capacity of an ecosystem to respond to a perturbation or disturbance by resisting damage and recovering quickly (Holling, 1973). In a recent paper, Davis et al. (2013)

suggested that groundwater-dominated habitats in Australian deserts have a theoretically higher likelihood of persistence under future (and probably past) climate change than surface water-dominated habitats because they are largely independent of local precipitation, posing them as resilient habitats. As an example of resilience, Davis explains that, in this kind of deserts, resilience implies that a system or organism will change when water is scarce, but it will return to the previous state when water returns. For archaeological goals, resilience refers to some degree of resistance and spatial-temporal stability ("continuity") of the studied system (natural or cultural). This does not imply that the system remains unchanged, but rather that the system possesses a certain degree of flexibility to adapt to moderated levels of change, as well as the ability to reset the system to adjust to new conditions without losing its basic functionality (or, from the human point of view, its "ecosystemic services").

An accurate definition of ecological refugia is needed in order to understand the role of certain habitat as refugia through time. Keppel et al. (2012) proposed a habitat-based definition of refugia: they are sites to which biota retreat, persist in and potentially expand from under changing environmental conditions. To identify these kinds of habitats, Dobrowski (2011) states that refugia are places where local climate is decoupled from regional climate. Following Davis et al. (2013), it is also necessary to distinguish between macrorefugia and microrefugia. The former has been defined as regions with favorable climates, while the latter are small areas of favorable climate within a region of largely unfavorable climate (Provan and Bennett, 2008; Rull, 2009; Ashcroft et al., 2012). So, for archaeological goals, we can understand refugia as restricted habitats that convey spatial and temporal resistance and/or resilience to biotic communities (including humans) affected by disturbances, or as places where the negative effects of the disturbance are lower than in the surrounding area (Sedell et al., 1990).

The discussion about refugia and resilient habitats implicitly involves the concept of fragmentation (Yacobaccio, 2013). Frag-
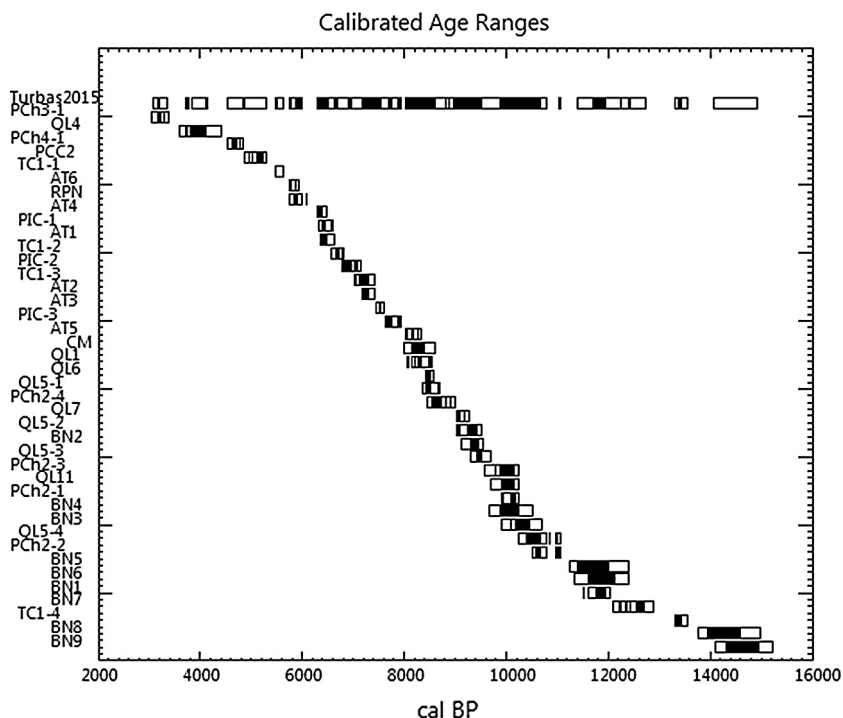

Fig. 1. Peat calibrated radiocarbon dates of seven localities (Quebrada Lapao, Pastos Chicos, Inca Cueva, Barrancas, Alto Tocomar, Barro Negro and Ramadas) of the Dry Puna of Argentina. In the top a 2 σ sum of probabilities bar plot.

mentation can be produced by either human action or natural phenomena. It is defined as the process of dissection of natural systems into isolated parts. The effect of fragmentation on natural systems could be amplified by habitat loss, which occurs when the area of habitat suitable for a species or community and the number of biotic interactions are reduced (Hobbs et al., 2008). Fragmentation also generates spatial heterogeneity and, therefore, high spatial dependence, meaning that the number of resources per unit of area substantially varies with spatial location (Hobbs et al., 2008). In arid and semi-arid environments, ecological processes are shaped by temporal variation in primary production and in the availability of surface water (see Thomas, 1997). Environmental pulses of resource availability are interrupted by periods of resource scarcity in decadal, annual or seasonal scales. In these cases, when heterogeneity is high, consumers (both wildlife and humans), must overcome the risk of having insufficient resources for sustaining population in certain habitat areas or patches. For this reason, patch connectivity has a significant impact on population dynamics; mobility operates as a mechanism to create connectivity between sectors of a fragmented landscape.

How can we define the history of hunter-gatherer habitats along the Holocene in the Dry Puna of Argentina? As mentioned in the previous section, since the end of the LGM, climate change has had an enormous impact on environmental factors, such as the distribution of plant communities, the size and distribution of faunal populations, the frequency of soil development, the abundance of wetlands, etc. We consider that the study of the frequency and distribution of hydromorphic soils (peatlands) is useful to explore the availability of wetlands through time. Consequently, it constitutes an effective proxy of resource structure, since it is an indicator of localities where the availability of water could have sustained primary and secondary biomass.

As an example of this kind of ecological rearrangement, Fig. 1 displays the full set of radiocarbon dates (N = 40) from peat deposits dated by our research team in the Dry Puna.

The frequency and distribution of dates from those peat deposits are consistent with the regional moisture history, as summarized in the previous section. This fact provides support to the claim that broad datasets of soils dates are a reliable proxy of regional/supra-regional moisture changes, and of the relative abundance of wetlands through time (Charman, 2007).

Considering that these dates were obtained from seven localities (Fig. 2), they suggest a high degree of continuity of soil development in the Dry Puna of Argentina, with no major gaps from 9500 to 5700 BP (11,000–6000 cal BP). However, several hiatuses are observed before and after this period, both in the final Pleis-
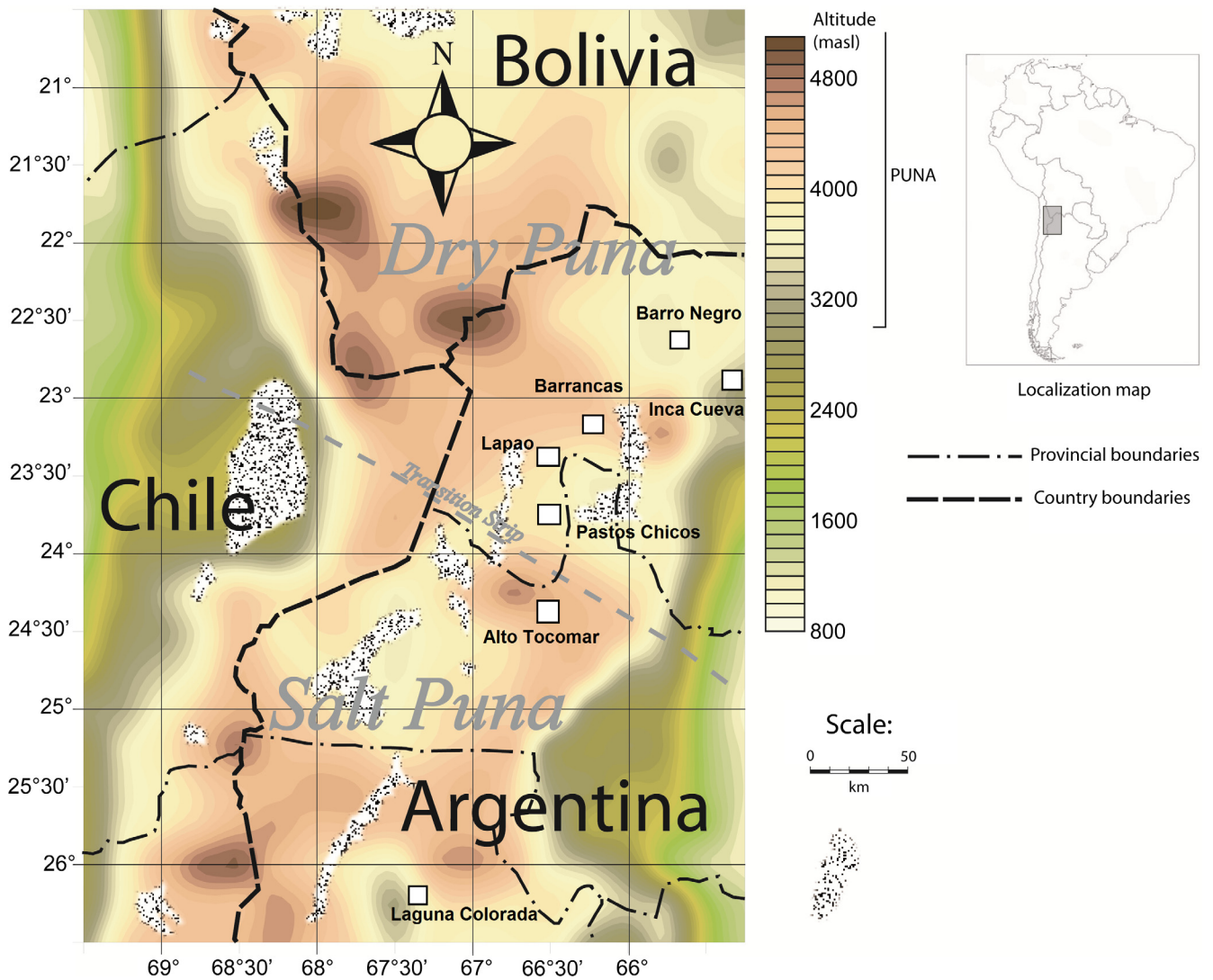

Fig. 2. Location map of the peat profiles analyzed in the text.

tocene and in the Mid-Holocene II. As the sample is still small, these hiatuses must not be over-estimated; however, they seem to evidence phases of temporal discontinuity of productive patches in a regional scale. The process that took place after 5700 BP (6470 cal BP) could be described as a process of habitat fragmentation, amplified by habitat loss.

Another dimension of change in wetland history can be explored using this dataset. If we analyze the best-dated localities with more continuous records individually (Quebrada de Lapao, Pastos Chicos, and Barrancas), it is possible to evaluate the availability of these particular loci in the past, as attractive human habitats. On one hand, two of these localities show a relatively abrupt interruption in their sequences, evidencing their transformation into a non-attractive habitat: (1) The Q. Lapao sequence is abruptly interrupted at *ca.* 7500 BP (8270 cal BP), with some evidence of recovery during a brief period *ca.* 3700 BP (3980 cal BP), and (2) Pastos Chicos, somewhat more resilient, shows a gradual trend that ends in the interruption in its sequence after 6300 BP (7140 cal BP), with recurrent events of recovery after 4200 BP (4680 cal BP). On the other hand, Barrancas' wetlands were remarkably resilient, oscillating between palustrine and fluvial characteristics, from 11,500 BP (13.300 cal BP) to at least 3000 BP (3100 cal BP). Like Barrancas, Inca Cueva and Alto Tocomar also appear to have been resilient wetlands, where habitats were available at least until the end of the Mid-Holocene I. Although the preliminary state of our studies in both locations prevents us from drawing more definite conclusions, their characteristics (size, productivity, stability, etc.) and history allow us to infer that Barrancas, Inca Cueva and Alto Tocomar may have functioned as ecologic refugia during the Mid-Holocene's hyper-arid conditions. The first two cases described, Q. Lapao and Pastos Chicos, were resilient ecosystems until the Mid-Holocene, after which these habitats were lost.

5. Discontinuities in the use of animal resources

In previous works, it has been proposed that a process of specialization and intensification in the use of camelids (both *Lama guanicoe* and *Vicugna vicugna*) occurred through time, which eventually culminated in the domestication of guanacos towards the end of the Mid-Holocene (Yacobaccio, 2013; Yacobaccio and Vilá, 2013). The increase in camelid bone remains and the decrease in the representation of other taxa (mostly small fauna) were used as the main zooarchaeological indicators. In this paper, we will use several diversity indices to approach the same problem, highlighting the sensibility of these set of indices to show discontinuities in the zooarchaeological record. We assume that the process of specialization/intensification implies an increase in the dominance of the biological species intensified, as well as a decrease in species diversity through time.

We measures diversity using the Shannon (H) and Dominance (D) indices. The H index accounts for abundance and evenness of
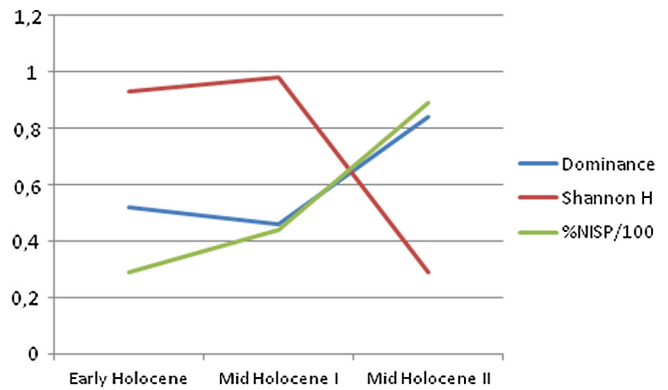

Fig. 3. Shannon H, Dominance D, and %NISP/100 through time sub-period. Note the abrupt change in the Middle Holocene II around 5400 BP (6200 cal BP).
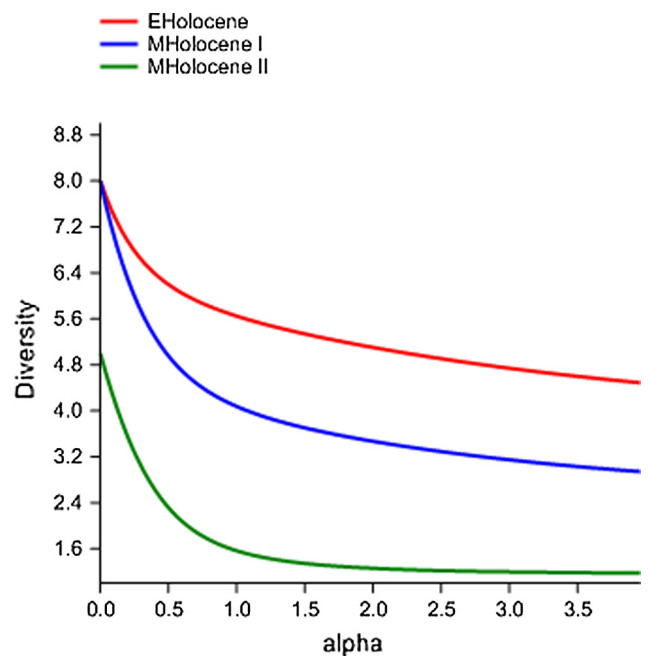

Fig. 4. Diversity profile using Renyi's index family. They are comparable because each curve do not intersect each other. The Early Holocene is the more diverse. Mid Holocene is intermediate (MHI < EH > MHII), and the Mid Holocene II is the less diverse (EH > MHI > MHII).

the species present in an assemblage; the index increases as both the richness and the evenness of the community rise. On the contrary, D is a measure of dominance, so as D increases, diversity decreases. Both indices are complementary; in archaeology, they

Table 1
Taxa from sites of the Puna de Atacama (Chile and Argentina). Summarized data of NISP and percent of NISP by sub-period. Exact data in Yacobaccio (2013: Tables 1–3).

Taxa	Early Holocene	%	Mid Holocene 1	%	Mid Holocene II	%
Artiodactyla	2142	16	1018	19.87	371	1.32
Camelidae	3868	29.71	2235	43.64	24,837	88.67
Cervidae	73	0.56	10	0.19	0	0
Chinchillidae	2817	21.64	817	15.95	2355	8.4
Caviidae	1382	10.61	12	0.23	0	0
Ctenomys sp	1576	12.1	54	1.05	313	1.11
Avis	1149	8.82	51	0.99	133	0.47
Dasipodidae	10	0.07	924	18.04	0	0
	13,017		5121		28,009	
N sites	10		7		10	

can be used as a proxy of generalized vs. specialized use of resources.

We also constructed diversity profiles using PAST 3.1 software (Hammer, 2015). Diversity profiles statistically compare diversities in several samples through a family of diversity indices dependent upon a single continuous parameter. In this case we used the exponential Renyi index against a scale parameter, i.e. the total number of species ($\alpha = 0$). The exponential Renyi index shows varying sensibilities to rare and abundant species. This family of indices is the most useful method for measuring diversity in communities of different sizes (Tóthmérész, 1995). In zooarchaeological samples, the Renyi index can be taken as a proxy of the alpha diversity (Whittaker, 1972). Whittaker proposed that the total specific diversity in a landscape (gamma diversity) is determined by two different elements: the mean species diversity in sites or habitats at a more local scale (alpha diversity) and the differentiation among those habitats (beta diversity).

Alpha diversity is suitable for discussing variation when the samples are taken at the site level. For the purposes of this study, the individual archaeological sites included in our sample can be treated as patches, given that the faunal record recovered from each site is considered representative of the patch in which the site is located (Binford, 2001). This reasoning allows us to generate two more expectations:

1. If diversity increases through time, the patches were used according to gross species abundance;
2. If diversity decreases through time, the patches were used in a specialized way.

Of course, the use of patches can change for different reasons (a modification in mobility or subsistence strategy, diminution of the abundance of resources in patches, etc). However, this would also be reflected in the diversity indices. We analyzed site-samples of
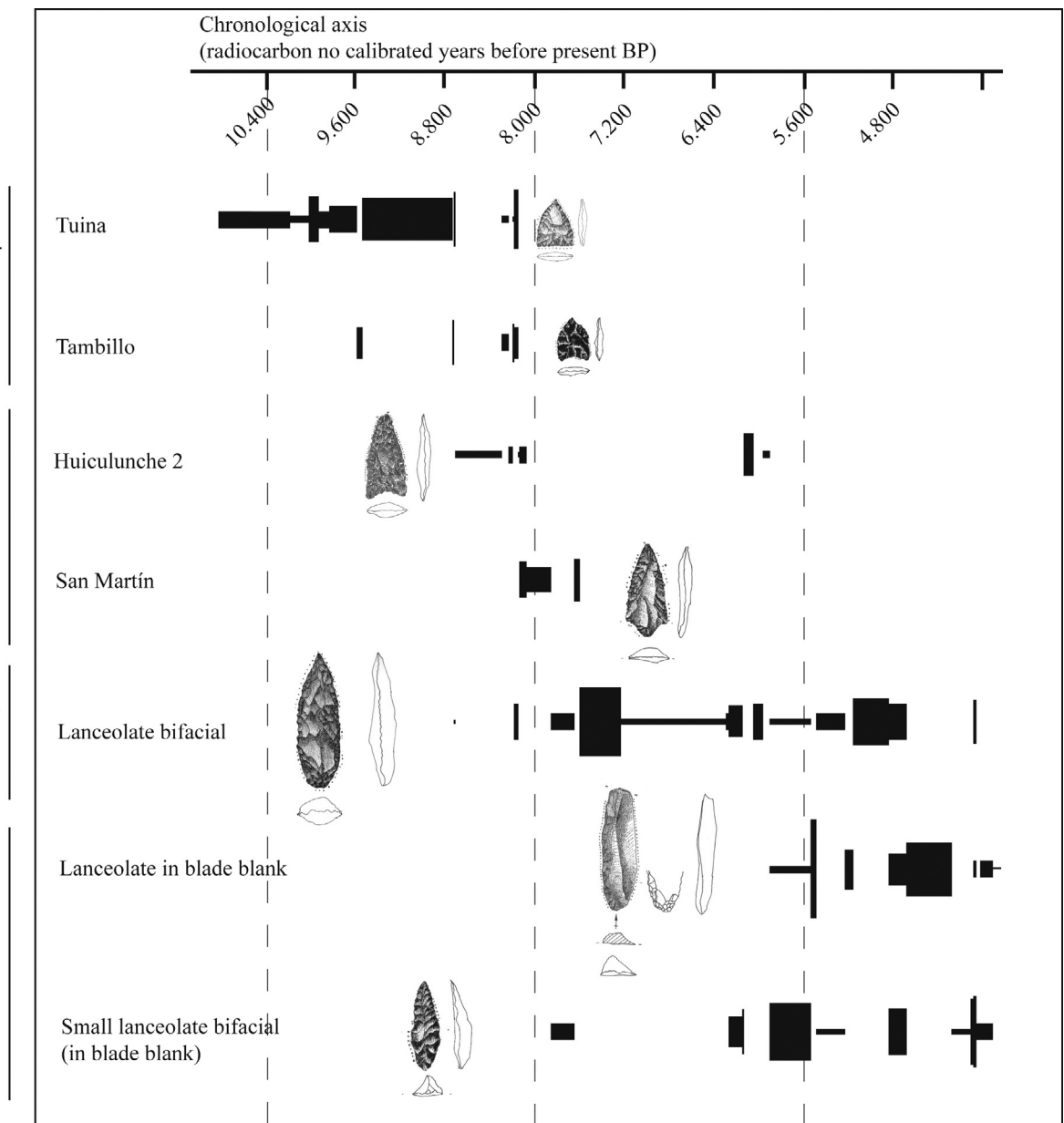

Fig. 5. Seriation graph of projectile points from the Puna de Atacama (Chile and Argentina).

fauna sorted by the different phases of the Holocene in order to explore the use of the different patches in each phase. Since different patches are represented in the sample, the conclusions drawn for each sub-period is significant in a regional scale.

Table 1 summarizes taxa abundance for 27 sites/levels in the Puna de Atacama (Chile and Argentina; see exact samples in Yacobaccio, 2013: Tables 1–3). Camelid bone remains increase through time from 29.7% to nearly 89%, while other taxa are dramatically reduced. Small fauna (small rodents, Avis, Xenarthra) were used locally, and in some cases they were also abundant, but they have an uneven regional representation. Only camelids, chinchillids and, to a lesser extent, cervids, have a truly regional distribution.

The Shannon H index (Fig. 3) increases steadily between the Early Holocene and the Mid-Holocene I, followed by a sudden drop in the next sub-period. Conversely, the Dominance D index rises between the Mid-Holocene I and II, correlated with the relative representation of camelid bone remains (%NISP/100) (Fig. 3). The Diversity profiles (Fig. 4) show a decrease in diversity towards the Mid-Holocene II, thus lending support to the hypothesis regarding animal resource specialization. The oldest radiocarbon dates associated to this change in diversity indices have a pooled mean of 5369 ± 39 BP (6177 ± 39 cal BP). We will discuss the significance of this date below.

The evolution of diversity suggests that before ca. 5400 BP (6200 cal BP), hunter-gatherers had a mostly generalized subsistence base on a regional scale, and the different patches were used according to gross species abundance, with the exception of patches that offered a limited number of resources but in great abundance, e.g. sites located near Ctenomys spp colonies (Tambillo, Pintoscayoc) or shallow lagoons (Avis, Tulan 68). After 5400 BP, a specialized economic system emerged, and patches were used mainly to exploit the focal resource. This coincides with the appearance of protecting herding, which means human intervention in a guanaco population, or population subgroups, whose individuals are protected from its non-human predators and are provided with facilitated access to feeding areas (Yacobaccio and Vilá, 2013). This promoted a closer relationship between people and camelids, which eventually led to the domestication of guanaco. There is an early date for the beginning of this process at 6200 BP (7100 cal BP), but the evidence of protective herding increases between 5100 and 4200 BP (5800 and 4700 cal BP).

6. Discontinuities in lithic technology

Diagnostic artifacts such as projectile points and tools made from blade knapping techniques can be used to elaborate chronological series. In a previous work, one of us (Hoguin, 2015) made a seriation analysis on a regional scale by counting the frequencies of projectile point types in every archaeological site and site level in the Dry Puna. These values were transformed using the log function, in order to avoid sample size problems (0 values were converted as 0.1; see Hoguin, 2015). Fig. 5 shows the change in relative abundance of projectile points through time. Several discontinuities are evident, possibly due to the fragmentary nature of the archaeological record. In some cases, discontinuities are contained in a well-defined period – e.g. tools made on blades- but, in other cases, artifact types are spread along a relative long time-
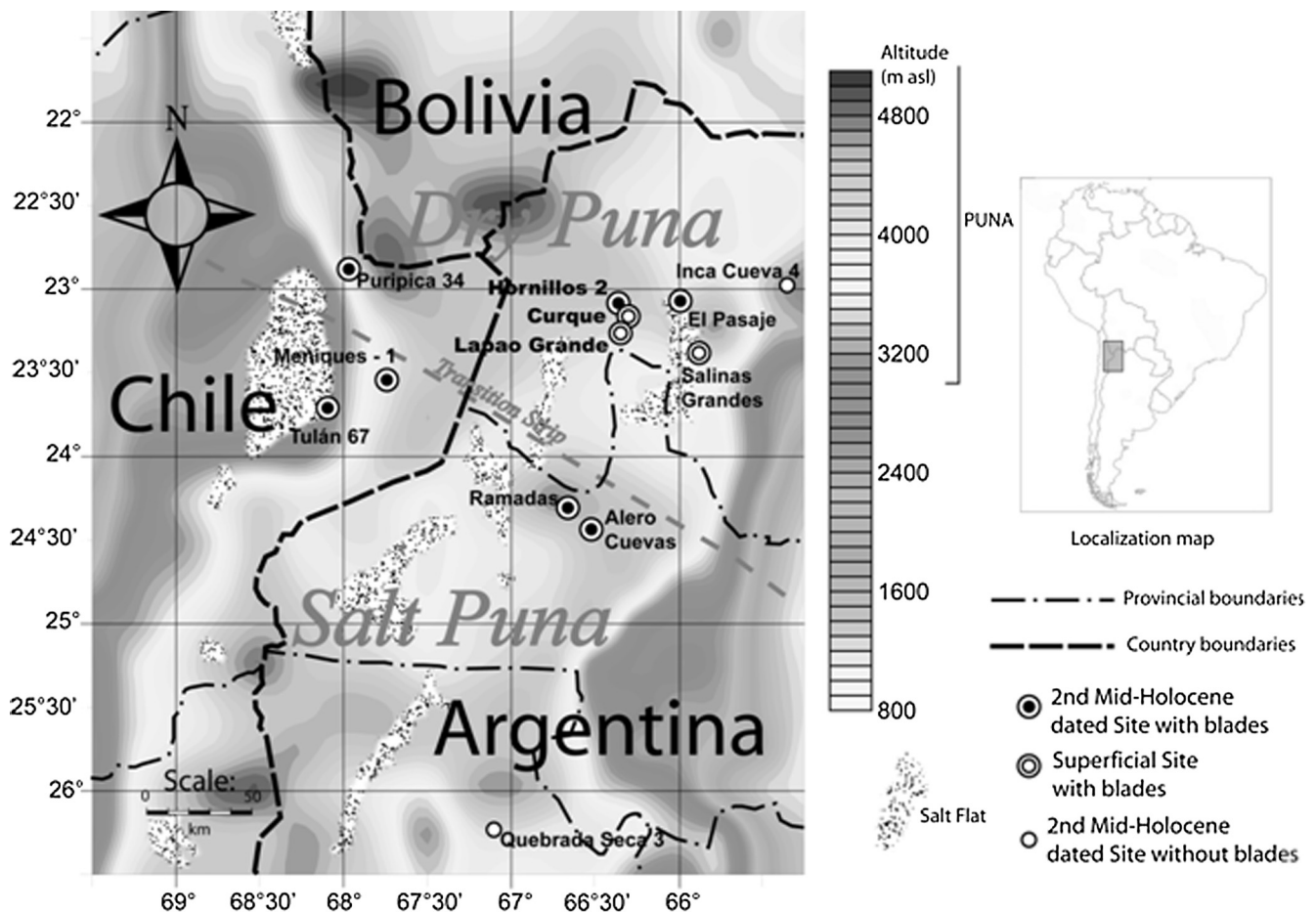

Fig. 6. Map showing the sites with blade technology in the Puna of Argentina and Chile during Middle Holocene II.

span – e.g. elongated triangular projectile points. An important discontinuity is recorded between *ca.* 8800 and 7800 BP (9000 and 8760 cal BP), as evidenced by the abrupt, consecutive appearance and disappearance of three projectile point types: Tambillo, Huiculunche 2 and San Martin. The transition between the Early Holocene and Mid-Holocene also shows the greatest variability of blanks generated by different knapping methods and of tools manufactured through different shaping techniques. The initial Mid-Holocene was clearly a period that presented important technological changes, including a fast succession of different techniques and tools.

Another significant technological change occurred between 6300 and 5600 BP (7100–6350 cal BP) at a regional scale: the appearance of blade knapping (Fig. 6). It seems to have appeared at first as a Type C method, defined as a technique that produces a very small number of blanks -one or two series of approximately three blades. In fact, the archaeological assemblages for this period present very low percentages of blades. However, these assemblages also include blade-like tools produced from bifacial shaping (Hoguin, 2014), which constituted a technological innovation in the area. Later, during the Mid-Holocene II, blade production in archaeological assemblages became more important (and dominant in some cases) at a regional scale, as mentioned in Jujuy at Susques (Hoguin, 2014), and Río Grande (Fernández, 1983); in Salta at Pastos Grandes, Salar de Pocitos (López, 2008, 2012), and Ramadas (Restifo, 2013); and, finally in Northern Chile at Puripica 1 and 33, Meñiques 1, Capur 4, Miscanti 1, Tulán 52 and 67 (Núñez et al., 2005, 2006).

The onset of blade production marked an important technological change that began during the Mid-Holocene I and continued to evolve during the Mid-Holocene II to become the dominant production system at the regional scale. However, this technology is not represented in the archaeological record in the Salt Puna further south, in the province of Catamarca (Aschero and Hocsman, 2011), nor in the Humid Puna in Southern Peru (Aldenderfer and Flores Blanco, 2011). As of today, blade production seems to have been a spatially restricted phenomenon centered in the Dry Puna of Argentina.

7. Discussion and conclusion

Recently, two studies based on radiocarbon data sets tried to infer the anthropogenic signal and/or demographic pattern for the South Central Andes (Gayó et al., 2013; Muscio and López, 2016). Although the studies have partially-overlapping radiocarbon dates, they have a different spatial scope. Their results agree, at least partially, in suggesting a rapid fall of the anthropogenic signal during the Mid-Holocene. Both studies also show that human occupation of the highlands of the South Central Andes probably presented a "see-saw" pattern, i.e. signals of human occupation exhibit sharp, consecutive increases and decreases, in centennial or millennial scales. We used the results presented by Muscio and López (2016) because they are germane to the spatial and temporal scope of this paper. These authors determined that the anthropogenic signal increased with a maximum rate during the Early Holocene and Mid-Holocene I, followed by a decline between 7900–7500 cal BP, and 6900–6300 cal BP.

Paleoenvironmental evidence has provided highly relevant information for the discussion regarding space and time (dis)continuities in the availability of human habitats along the Holocene in the Dry Puna. The availability of suitable human habitats seems to have been high between *ca.* 9500–5700 BP (11,000–6000 cal BP-maximum rate of increase in anthropogenic signal for Muscio and López, 2016) with no major gaps observable in radiocarbon data sets obtained from peatlands. Later, several hiatuses are

noticeable in the Mid-Holocene II. This regional trend, along with the particular environmental history of each locus, seems to be well correlated with the general social trajectories in the region as inferred from the archaeological record. For instance, before *ca.* 5400 BP (6200 cal BP) and for the most part, hunter-gatherers had a generalized subsistence base on a regional scale, and the different patches were used according to gross species abundance. Later on, a specialized economic system emerged where patches were mainly used to obtain high- ranked animal species, such as camelids. A major technological change happened almost synchronously (between 6300 and 5600 BP [7100 and 6350 cal BP]) at a regional scale, i.e. the emergence of blade knapping techniques. It is worth noting here that innovations such as the appearance of short-lived projectile points -San Martin, Huiculunche 2, and Tambillo- occurred before the first regional drop in anthropogenic signal. Economic specialization including camelid protection practices (5800–4700 cal BP), and the appearance of blade knapping technology (*ca.* 6177 cal BP), occurred after the second drop of anthropogenic signal and at the beginning of an anthropogenic signal increase period that reached its maximum rate at 4700 cal BP. This date correlates quite well with the appearance of corrals or courtyards in the archaeological record, which points towards an intensification of the camelid domestication process.

We believe that this evidence clearly illustrates the fact that whereas limited modifications in mobility patterns may be sufficient to deal with the mean variability in resilient environments – e.g. during the Mid-Holocene I-, processes of habitat loss such as those that occurred between 6800 and 6200 cal BP can trigger significant changes in a range of social spheres, including demography, economy and technology. This implies that a few of the remaining resilient habitats, albeit more scattered temporally and spatially, may have functioned as human refugia during these shortage periods, as shown by the regional drop in the anthropogenic signal.

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