Bolas, projectile points and hunting technologies in Southern Patagonia (Santa Cruz, Argentina) during the Late Holocene

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Abstract:

The late Holocene in the central-western region of the Santa Cruz province (Southern Patagonia, Argentina) was characterized by the occurrence of climatic and environmental change processes which implied a progressive drought, markedly recorded after ca. 3000 years BP. Peopling processes in the region during this period implied mobility strategies that included residential mobility in lowlands combined with logistical mobility in highlands. In this changing context, local hunter-gatherer groups used a variety of weapons for obtaining prey: *bolas*, bow and arrow and spears or darts.

In this context, this work analyses the distribution and chronology of the lithic components of these technologies (arrow and spear/dart stone points and stone balls) including evidence of their manufacture (preforms and raw materials). For this, we consider different environments (different low basins and high basins and plateaus) and different types of sites (open air site, basaltic wall, rock shelter, hunting blind and burial). The aim is to assess the role of these technologies in the context of changes in mobility strategies and landscape use. The evidence collected suggests that these three technologies had important differences in their use and production, especially in their replacement potential, manufacturing possibilities, transport and repair. These differences possibly made them complementary. Our main argument suggests that hunter-gatherers diversified technologies, specifically those used to obtain prey, in a context of landscape and resource fragmentation. Therefore, there was a complementary but differential use of technologies and not a process of adoption and abandonment. New technical options were incorporated into previously established ones, thus offering greater flexibility to the subsistence system.

Keywords: *bolas*; bow and arrow; spear; Late Holocene; climatic change

1. Introduction

The Late Holocene in the central-western area of Santa Cruz province (Argentina) was a period where climatic and environmental changes occurred, caused by a drop in regional

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humidity levels (Stine & Stine 1990). Towards 3000 and again towards 900 years B.P. great droughts were registered; the latter coincides with the worldwide phenomenon known as the Medieval Climatic Anomaly (Ariztegui *et al.* 2010; Moy *et al.* 2008; Stine 1994; Stine & Stine 1990). Archaeological investigations in the area have established a relation between these changes and modifications in the organization of hunter-gatherers who inhabited the region (Cassiodoro *et al.* 2013; Goñi 2010: 251; Re *et al.* 2017; among others). Thus, a new configuration of the peopling process would have emerged and the diverse ecological sectors in the area were occupied differently. Therefore, areas with low altitude and less severe environmental conditions were occupied more permanently with year-round occupations and a residential use, while areas with higher altitudes were visited seasonally and used logistically, mainly with the specific aim of resources procurement (Goñi *et al.* 2002; 2006; among others).

After European contact, specifically as from the 16th century, indigenous populations from the region experienced a series of changes, even though hunter-gatherer practices persisted. The main innovation was the adoption of horse as a means of transport towards the 18th century that brought changes in mobility, technology and subsistence (Martinic 1995: 73).

Previous works have revealed that variations in the use of the landscape in the region also included changes in the technology. After 2500 years B.P. and during the Late Holocene changes in the types of projectile points, the use of raw materials and the proliferation of grinding technology is recorded (Agnolin 2019: 376; Cassiodoro 2011: 175; Cassiodoro *et al.* 2013; 2014; Flores Coni 2018: 523). Towards later moments, around the last 1000 years B.P., investigations revealed the incorporation of new technologies as ceramics, the introduction of bow and arrow and the more frequent use of *bolas* (Agnolin *et al.* 2019; Cassiodoro *et al.* 2013; Chaile *et al.* 2020). After horse introduction, ethnographic sources indicate the adoption of a wide array of European technologies and a change in weapons used. During this period the use of the boleadora predominated and the bow and arrow and the spear were abandoned, or their use drastically decreased till the 20th century (González 1953; Martinic 1995: 208; Saletta & Sacchi 2019).

This work seeks to deepen the available knowledge regarding technology and hunting strategies during the Late Holocene. We evaluate to what degree the environmental changes from this period influenced the diverse modalities and technological alternatives used in resources procurement. Therefore, we present a study based on the distribution, frequency and general characteristics of two technologies: projectile points and lithic *bolas*. The first related to spears, darts and bow and arrow, and the second used in *boleadoras*. Thus, through an analysis of technological organization (Nelson 1991) we evaluate the use of different weapon systems to discuss hunter-gatherer´s strategies. Hence, the aim is to identify the characteristics of manufacture, transport, use and discard of these types of instruments to discuss the use of each of these technologies in a broad temporal and spatial scale. Additionally, we address the relation the relation between different weapons systems, their complementarity and the existence of replacement among them. Previous works were based on a smaller scale and sample (Agnolin *et al.* 2019; Belardi *et al.* 2005). In this case, the area under study has an approximate size of 7500 km2 and includes varied environmental sectors. Chronologies include the last 3000 years B.P.

1.1. Region under study and chronology

The central-western portion of Santa Cruz province (Patagonia, Argentina) comprises lowlands -mainly lake basins- and highlands and plateaus (Figure 1), which were occupied by hunter-gatherer groups in the past until the beginning of 20th century. These groups were

mainly oriented to the hunting of guanaco (*Lama guanicoe*), a medium- sized camelid (100 kg approximately). As a second option they also hunted choique (*Rhea pennata*) a big flightless bird of 25 kg and small mammals like foxes and edentates, which were only a minimal part of the diet (Dellepiane 2019: 298; Rindel 2009: 391; Rindel & Bourlot 2014).

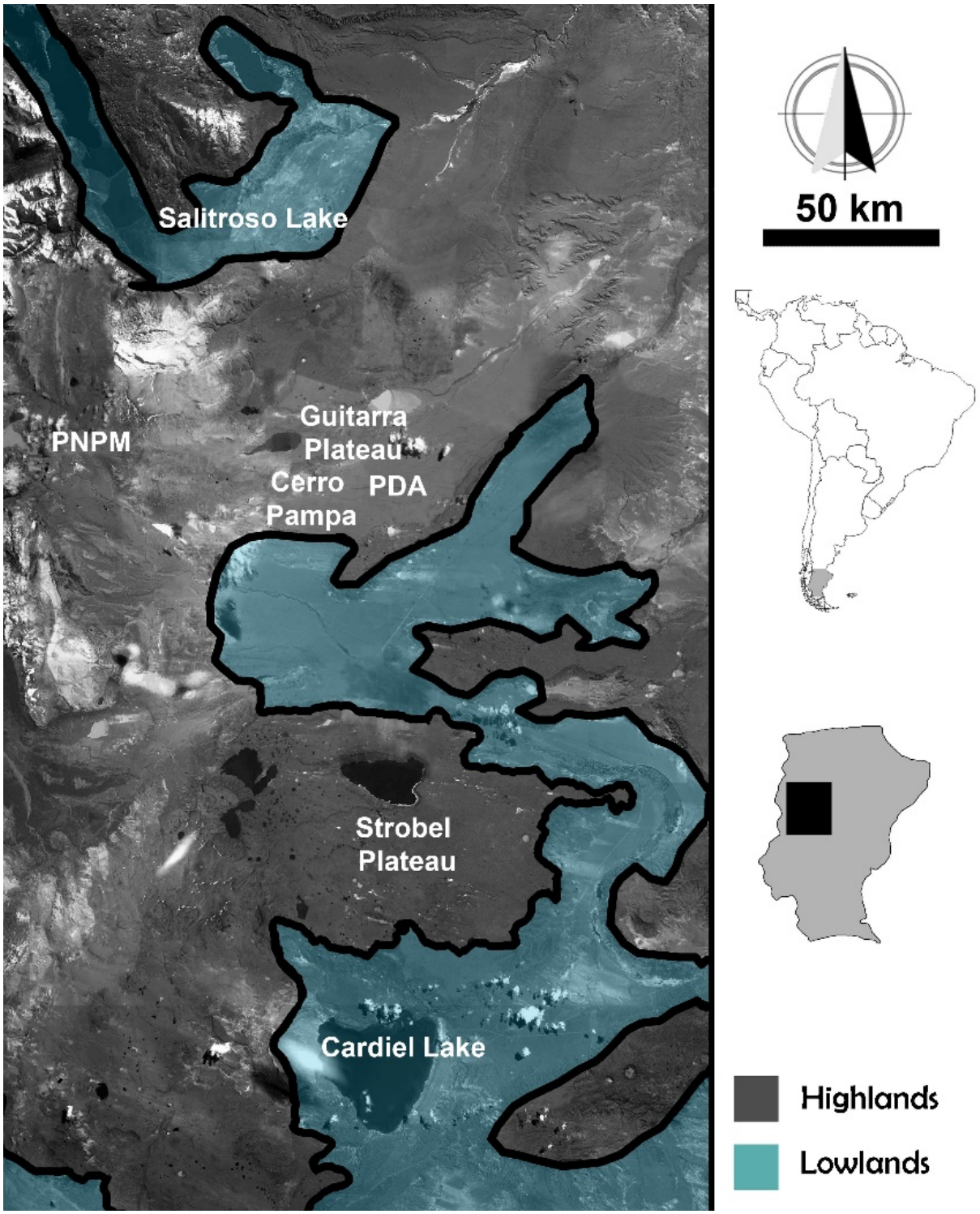

Figure 1. Study region. References: PNPM: Parque Nacional Perito Moreno, PDA: Pampa del Asador.
Figura 1. Región de estudio. Referencias: PNPM: Parque Nacional Perito Moreno, PDA: Pampa del Asador.

The region is characterized by the presence of a steppe vegetation and a semi-arid climate, with marked seasons. The areas under study include Cardiel Lake basin and Salitroso

Lake basin which are approximately 300 m a.s.l. with excellent conditions for year-round occupations and diverse resources, specifically shelter and firewood. Also, highlands are included in this study such as Strobel Plateau, Guitarra Plateau and Pampa del Asador (where Cerro Pampa is found) in altitudes over 700 m a.s.l. These areas concentrate resources during the end of spring and in summer, especially water and guanacos, though there is scarce firewood. During winter, heavy snowfalls and a great accumulation of snow occurs, specifically over 900 m a.s.l.

The analyzed chronology ranges from approximately 3000 years B.P. till the beginning of the 20th century, when lands were occupied by Argentinian and European shepherds. As previously mentioned, the period considered was characterized by arid conditions that implied a fragmented scenery in terms of the availability of resources.

The lithic raw materials in the region are diverse and abundant, even though there are variations in the different areas. Thus, while siliceous rocks, basalts, riolites, andesites and tuffs are frequent in many areas from the region (Agnolin *et al.* 2018; Cassiodoro *et al.* 2015), Pampa del Asador stands out as the main regional source of obsidian (Espinosa & Goñi 1999; Stern 2018). On the other hand, Strobel Plateau presents a limited availability of rocks, mainly tuff and siliceous rocks in low frequency (Flores Coni 2019).

1.2. Weapons in context

The hunting technologies used during the last 3000 years presented some distinctive characteristics. As for *bolas* (see Figure 2.A and 2.F), they are lithic artefacts whose manufacture requires several stages and a considerable investment of energy compared to other artefacts (Vecchi 2010: 107). They are generally manufactured in raw materials with more mass and toughness (Vecchi 2010: 76) which gives them a potentially long life use. In the study region, previous works have stated that this technology was standardized in dimensions and morphology, with limited variability in morphologies and sizes (Agnolin *et al.* 2019). This homogeneity could be the result of both the use of a design in a diverse way or a specific functionality of the *bolas*. This is different to what was suggested for other areas in Southern Patagonia (Torres Elgueta & Morello 2011). The technological organization of these weapons was segmented in the landscape where manufacture activities were limited to areas of availability of raw materials and their use occurred in plateaus and low basins, sometimes at a considerable distance of the potential places of manufacture (Agnolin *et al.* 2019). Even though they could have been part of different weapon systems, such as hunting or for interpersonal conflict (Aschero 2018; González 1953; Gradin *et al.* 1979; Vecchi 2010: 76), its use would have been mainly related to hunting guanaco in open spaces using topographic traps in a disadvantage strategy (Agnolin *et al.* 2019, see also Vecchi 2010: 95). In the study region there is archaeological and ethnographic evidence of the use of *bolas* until the 20th century (Nuevo Delaunay 2013). A great number of *bolas* (n:46) found in Laguna del Potrero (Strobel Plateau), suggests their use for hunting in the surroundings of a lagoon during recent times, using it as a topographical trap and getting lost in the process (Nuevo Delaunay 2013). Its use was probably linked to hunting on horseback.

As for bow and arrow and spears or darts (see Figure 2.B, 2.C and 2.D), there is extensive regional and international literature. Basically, these papers state that both systems are flexible and work with a wide variety of prey and with multiple hunting strategies; however, they have several differences. Bow is more versatile, being more effective when capturing small animals, less dependent on disadvantage hunting techniques and is also more transportable (Cattelain 1997; Churchill 1993; Ratto 1991; Tomka 2013; Yu 2006). In the case of Southern Patagonia, bow and arrow are represented by Bird V type projectile points with stem widths smaller than 10 mm, while points related to darts or spears correspond to

type Bird IV with a wider stem width (Banegas *et al.* 2014; Bird 1988). Currently, the propulsion system of these latter points is unclear and were probably associated with both spears and atlatl-propelled darts. Since there is still some doubt on this point, we will use the term “spears”, but it should be considered it includes both throwing and hand-held spears as well as atlatl-propelled darts.

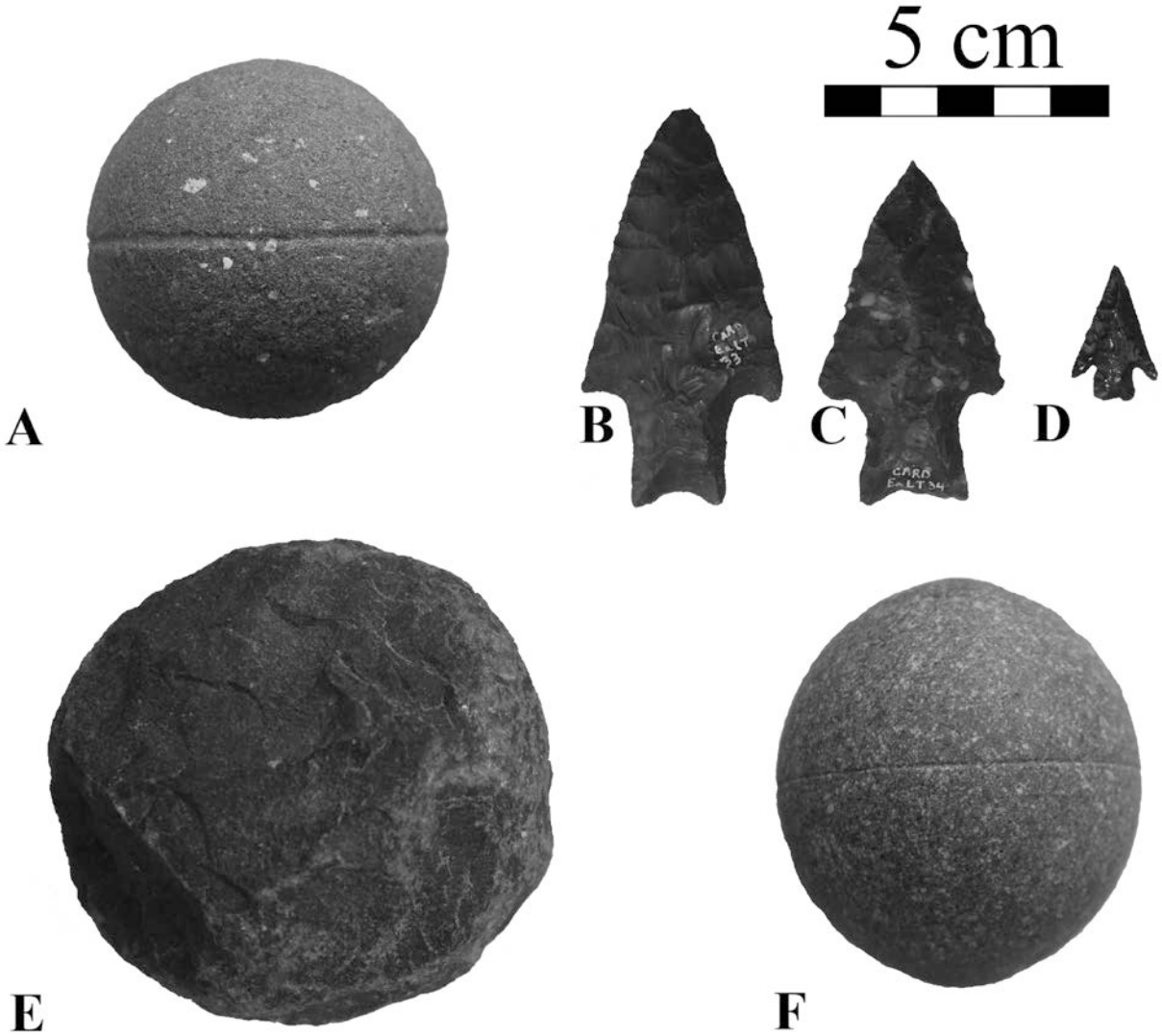

Figure 2. Projectile points and *bolas* examples. A and F: *Bolas*, B and C: Spear or dart points, D: Arrow point, E: *Bola* preform

Figura 2. Ejemplos de puntas de proyectil y *bolas*. A y F: *bolas*, B y C: puntas de lanza o dardo, D: punta de flecha, E: preforma de bola

Experimental studies have demonstrated that lithic points were manufactured on easily transportable blanks and probably only required few minutes (Nami 1987). In the case of Bird V type, studies suggest they would have been primarily manufactured from retouching of flakes by pressure, while Bird IV points would have been manufactured from bifaces (Nami 1997).

2. Sample and methods

Artefacts considered were projectile points and *bolas* as well as preforms for each of these artefact types. These were recovered in surface and stratigraphic contexts from sites assigned to the Late Holocene in Cardiel and Salitroso Lake basins, Strobel Plateau, Guitarra

Plateau and Pampa del Asador. In the latter area, the assemblages near Cerro Pampa are considered. This will be the reference for this area hereinafter.

The chronology of sites was assigned based on a variety of evidence: direct dating but also contextual given by their geomorphologic location (appearance of materials in dated geoforms) or the presence of diagnostic artefacts, that is artefacts with a well-known age (*i.e.*, ceramic and projectile points); this information has been detailed in previous works (Agnolin 2019: 54; 2021; Cassiodoro 2011: 12; Cassiodoro *et al.* 2013; Flores Coni 2018: 493, among others). Artefacts considered are those from sites while isolated artefacts were cited from previous publications (Agnolin *et al.* 2019; Belardi *et al.* 2003). The sample was obtained from 100 sites (20 from Lake Cardiel, 51 from Strobel Plateau, 4 from Cerro Pampa, 22 from Lake Salitroso and 3 from Guitarra Plateau).

The total sample is shown in Table 1. In some contexts, like the Strobel Plateau where there is a great frequency of fractured points, the minimum number of points was considered (Flores Coni 2018: 130), with the aim of avoiding bias by multiplying its value.

Table 1. Sample composition and provenience
Tabla 1. Composición de la muestra y proveniencia

Area	Projectile points <10mm	Projectile points >10mm	Projectile points preforms	Bolas	Bolas preforms	Total
Cardiel	12	41	10	6	9	78
Strobel	30	210	9	13	1	263
Cerro Pampa	22	34	4	3	1	64
Guitarra	2	9	1	1	-	13
Salitroso	42	66	7	10	3	128
Total	**108**	**360**	**31**	**33**	**14**	**546**

Projectile points correspond to different weapon systems. In this case, projectile points were grouped according to a 10 mm threshold for neck width: <10 mm related to bow and arrow, and > 10 mm for spear (Ratto 1991; Shott 1997). Even though there are plenty of discussions based on this threshold (*e.g.*, Erlandson *et al.* 2014; Hildebrandt & King 2012; Walde 2014, among others), considering raw materials and available preys, the 10 mm threshold is supported by ethnographic and archaeological information for continental Patagonia (Banegas *et al.* 2014; Ratto 2003: 32; 2012; Ratto & Marconetto 2012).

To obtain a detailed chronology of projectile point types and *bolas*, items selected were the ones that presented a clear dated context, and we considered only those contexts with C-14 dating. The information corresponds to 59 projectile points (20 with a neck width below 10 mm and 39 with 10 mm or more) and 2 *bolas* from all the region; the sample includes projectile points from Perito Moreno National Park (PMNP) located 45 km west from Cerro Pampa. Calibrated ages were obtained using CALIB. REV 7.0.1 program (Stuiver et al. 2013; Stuiver & Reimer 1993), Southern Hemisphere calibration curve (Hogg *et al.* 2013) and two sigma ranges. All the dated contexts were previously published (Aschero *et al.* 2005; Cassiodoro *et al.* 2013, 2019; Dellepiane 2019: 187; Espinosa *et al.* 2009; Goñi 2010: 303; Goñi *et al.* 2014; 2015; Re *et al.* 2017).

To evaluate artefact distribution and manufacture, we considered the type of site: open air sites (without structures), rock shelters, sites sheltered by basaltic walls and different stone structures: hunting blinds (*parapetos*) and burial mounds (*chenques*). In the regional archaeology, these different types of sites exhibit evidence of a differential use during the Late Holocene (Agnolin 2021; Cassiodoro 2011: 186; Dellepiane 2019: 342; Flores Coni 2018: 522; Goñi 2010: 251; Goñi *et al.* 2014, among others). Thus, residential activities are related to open air sites and basaltic walls in Cardiel Lake and to open air sites in Salitroso

Lake (Agnolin 2021; Bourlot 2004: 122; Cassiodoro 2011: 177). In these lake basins, logistical activities are mainly represented in rock shelters (Agnolin 2021; Guráieb 2012: 379; Rindel & Bourlot 2014). In highlands such as Strobel Plateau, logistical tasks were the main activities carried out, where stone structures exhibit less diversity of activities (mainly functioning as hunting stands and blinds) and rock walls more related to camps (Flores Coni 2018: 522). However, in some cases as in Cerro Pampa, stone structures evidence reveals more diversity in the activities carried out and probably included residential ones (Dellepiane & Cassiodoro 2019). We consider that in all cases artefacts were discarded as there is no evidence of cache, offering or other deposition modality, with the exception of burials (*chenques*).

3. Data Results

3.1. Chronology

When comparing uncalibrated and calibrated dates from different technologies in the region, there is evidence of overlapping and differences in the occurrence of each (see Figure 3.A, 3.B and 3.C). Bigger projectile points have a higher temporal depth, being the earliest record of 2300 C-14 B.P. in a site from Cardiel Lake (site GSLN) (Bourlot 2012: 57). This date is the earliest for this projectile point design north of Magallanes (Chile) (see Franco *et al.* 2010). Conversely, smaller points were incorporated later. The initial dates for these are around 1000 years B.P. in the Strobel Plateau, specifically in Laguna del Faldeo Verde site (Espinosa *et al.* 2009). It should be noted that a higher frequency of these smaller points is recorded after 500 years B.P. (see Figure 2A). The distribution of dates indicates a more restricted chronology for smaller points. Both systems overlap as from 1000 years B.P.

As for *bolas*, these are recorded since the first occupations in the region, dated to the Middle Holocene, in Cardiel Lake in Alero Los Guanacos I site (Agnolin *et al.* 2019) and in the PMNP (Cassiodoro & Piriz 2007). Even though there are scarce absolute dates related to *bolas*, previous works proposed an increase in the use of this technology after 800 years B.P. (Agnolin *et al.* 2019). Moreover, there is evidence of its use in historical times in the region, possibly related to hunting strategies including the horse (Nuevo Delaunay 2013).

3.2. Distribution

Bolas and both types of projectile points were recorded in all areas in the study region (Table 2). However, both types of points are considerably more frequent everywhere. Within this type of artefact, big projectile points (those with stem widths of 10 mm or more) are the most frequent.

Salitroso and Cerro Pampa exhibit a high proportion of small projectile points (with stem widths smaller than 10 mm), while the Strobel Plateau evidences a very low proportion, similar to what was recorded for Guitarra Plateau. Cardiel Lake reveals an intermediate position. As for *bolas*, even though they are considerably less frequent than projectile points, they are well represented in Cardiel Lake, with values closer to small projectile points.

In low lacustrine basins, Cardiel and Salitroso, both types of projectile points occur mainly in open air sites (Table 3). The occurrence of points in burials can be related to discard in contexts of violence, as two of them have been found embedded in the spinal column of an individual (García Guraieb *et al.* 2007). The rest of the points associated with burials are situated in the rock structures but have not been buried with individuals. On the contrary, Strobel Plateau has a marked difference in the distribution of points: smaller ones in basaltic walls, sites with a more generalized use; while bigger points are mainly recorded in hunting blinds (Flores Coni 2018: 536). In Cerro Pampa, both types of projectile points were mainly

discarded in hunting blinds. The latter probably had a more diverse use than those recorded in the Strobel Plateau (Dellepiane 2019: 324; Dellepiane & Cassiodoro 2019). In Guitarra Plateau bigger points are more frequent and these have an even distribution: they were recorded similarly in basaltic walls and hunting blinds. In general, bigger points appear to be discarded in diverse places, especially in hunting blinds. Smaller ones also appear in diverse contexts, although they are more frequently related to basaltic walls and open air residential sites.

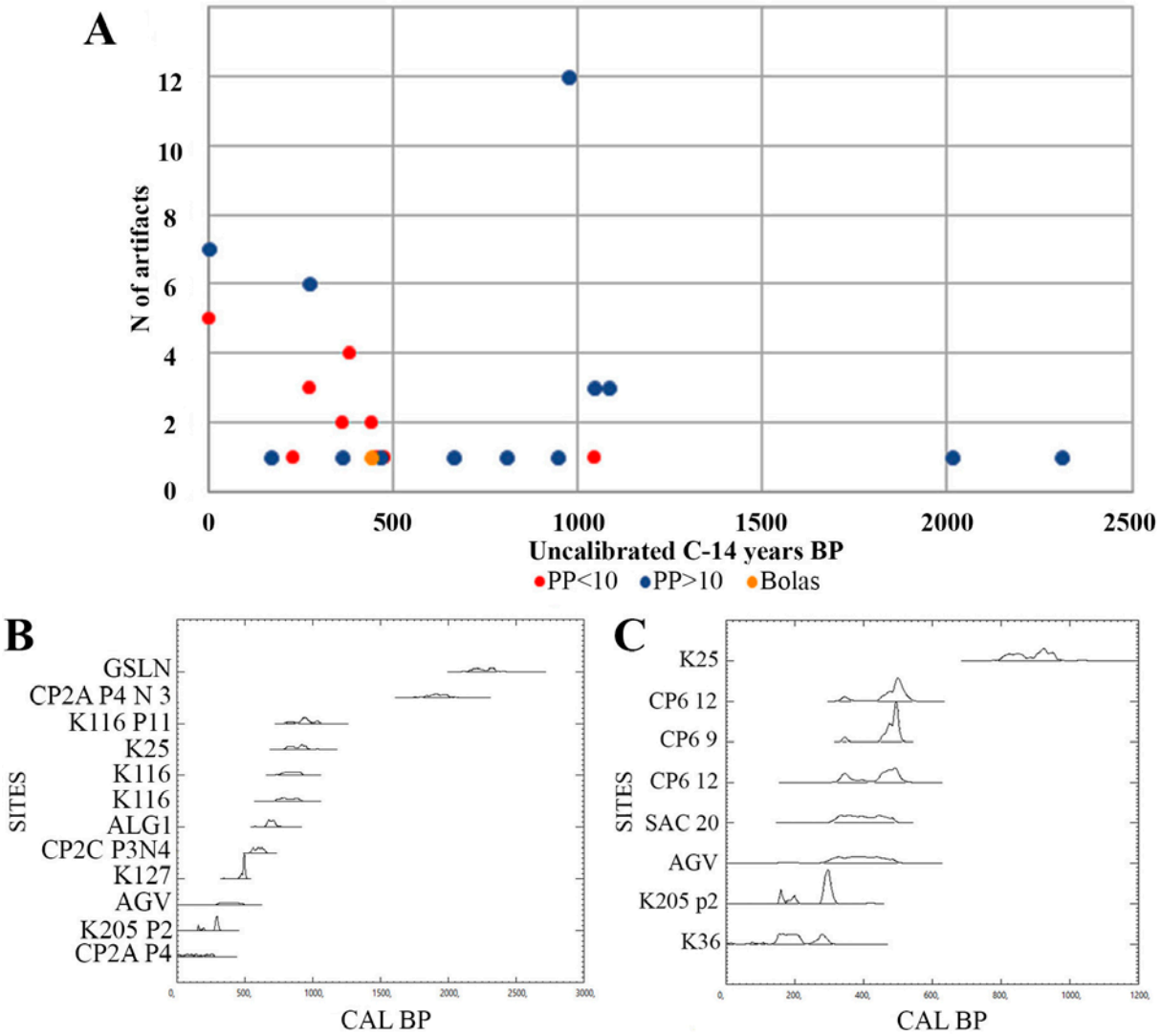

Figure 3: Projectile point and *bolas* C-14 chronology and frequencies. A: uncalibrated C-14 ages and frequencies of points and *bolas* in each date, B: calibrated dates for spear points, C: calibrated dates for arrow points. References: n PP<10: smaller projectile points, n PP>10: bigger projectile points. * We have included data from dated contexts from PMNP.

Figura 3: Cronología C-14 de puntas de proyectil y bolas y sus frecuencias. A: fechados C-14 no calibrados y frecuencias de puntas y bolas en cada sitio, B: fechados calibrados para puntas de lanza, C: fechados calibrados para puntas de flechas. Referencias: n PP<10: puntas de proyectil pequeñas, n PP>10: puntas de proyectil grandes. *fueron incluidos fechados del PNPM.

In the case of *bolas*, their distribution is also concentrated in open-air sites and basaltic walls, especially in the lower basins (Cardiel and Salitroso), and in Strobel mainly on basaltic walls. In contrast, the few *bolas* at Guitarra and Cerro Pampa appear on hunting blinds of diverse functionality, including residential use (Dellepiane & Cassiodoro 2019).

Table 2: Frequency and percentage of projectile point types and *bolas* in different areas. PP: projectile point.
Tabla 2: Frecuencia y porcentajes de puntas de proyectil y bolas en diferentes áreas. PP: punta de proyectil.

Artefact	**Cardiel**		**Strobel**		**Cerro Pampa**		**Guitarra**		**Salitroso**		**Total**	
	N	%	N	%	N	%	N	%	N	%	N	%
PP stem width <10 mm	12	20,3	30	11,8	22	37,3	2	16,7	42	35,6	108	21,5
PP stem width >10 mm	41	69,4	210	83,1	34	57,6	9	75	66	55,9	360	71,8
Bolas	6	10,2	13	5,1	3	5,1	1	8,3	10	8,4	33	6,6
Total	**59**	**99,9**	**253**	**100**	**59**	**100**	**12**	**100**	**118**	**99,9**	**501**	**99,9**

Table 3: Frequency of projectile point types and *bolas* in different types of sites.
Tabla 3: Frecuencia de tipos de puntas de proyectil y bolas en diferentes tipos de sitios.

Context	**Cardiel**			**Strobel**			**Cerro Pampa**			**Salitroso**			**Guitarra**		
	PP		**Bolas**	**PP**		**Bolas**	**PP**		**Bolas**	**PP**		**Bolas**	**PP**		**Bolas**
	< 10 mm	≥ 10 mm		< 10 mm	≥ 10 mm		< 10 mm	≥ 10 mm		< 10 mm	≥ 10 mm		< 10 mm	≥ 10 mm	
Open air site	9	24	3	-	-	-	1	6	1	40	59	10	-	-	-
Basaltic wall	1	11	3	23	34	11	-	-	-	-	-	-	1	4	-
Rock shelter	2	6	-	-	-	-	-	-	-	-	-	-	-	-	-
Stone structure (parapeto)	-	-	-	7	176	2	21	28	2	-	-	-	1	5	1
Stone structure (chenque)	0	0	0	-	-	-	-	-	-	2	7	-	-	-	-
Total	**12**	**41**	**6**	**30**	**210**	**13**	**22**	**34**	**3**	**42**	**66**	**10**	**2**	**9**	**1**

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In short, both types of projectile points and *bolas* occur in a variety of places, their distributions partially coincide. However, the *bolas* seem to have a more limited distribution than points, being especially centred in residential sites or multiple activities sites. In the lower basins, this involved the deposition of *bolas* in open air sites and basaltic walls, while in Cerro Pampa they are found both in open air sites and on hunting blinds used as hunting stands and residential structures, and in Strobel on basaltic walls. In contrast, projectile points have a more diverse distribution, being located both in residential sites and in those used for obtaining prey (hunting blinds in Strobel). According to this, both types of points partially share their distribution, but the replacement of bigger points would have been carried out frequently on hunting blinds used for hunting, something that does not occur in other weapon systems.

3.3 Manufacture

In order to discuss the technological organization involved in the manufacture of the different weapon systems, the characteristics of the preforms are considered below. A comparison is made with finished artefacts.

3.3.1. Preform distribution

The distribution of preforms suggests different places for *bola* and projectile point manufacture (Figure 4). In general terms, preforms appear in different types of sites although not equally represented. For instance, projectile point preforms (which at the moment cannot be assigned to arrow or spear) are recorded in low basins in open-air sites, while they are absent in rockshelters, where finished points have been found. In contrast, in highlands, points seem to have been manufactured mainly in hunting blinds and to a lesser extent in open-air sites and basaltic walls.

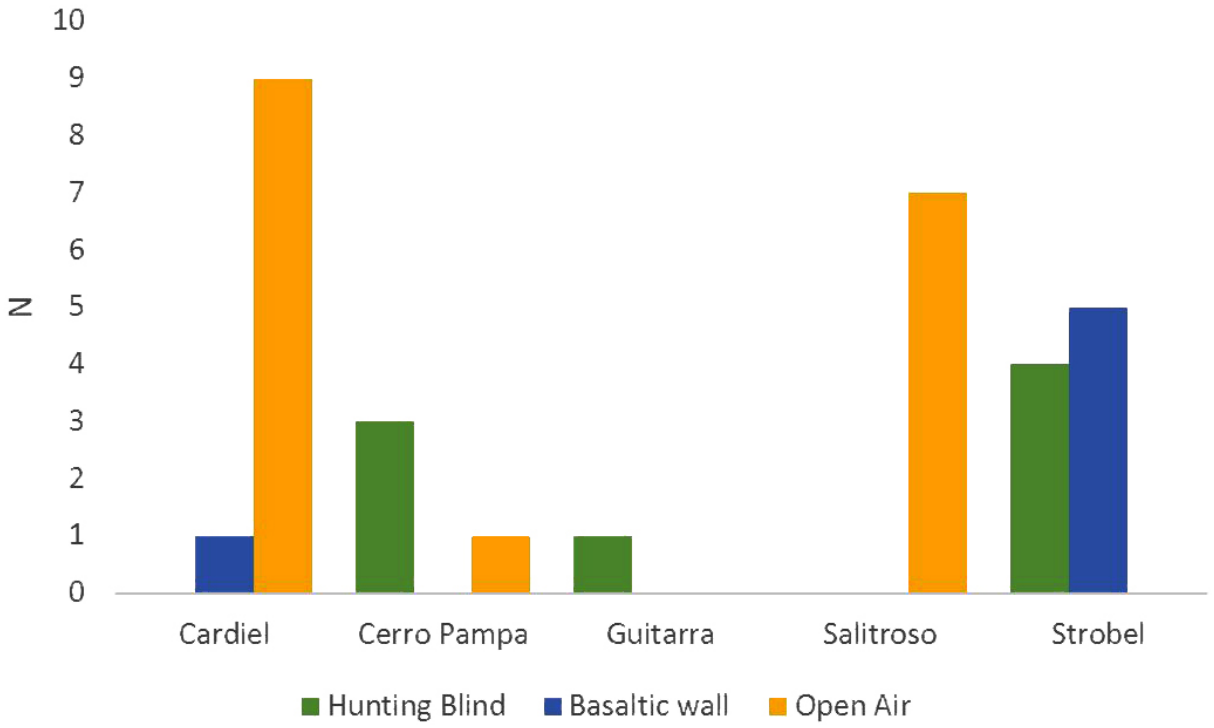

Figure 4: Distribution and frequency of projectile point preforms in different types of sites per area.
Figura 4: Distribución y frecuencia de preformas de puntas de proyectil en diferentes tipos de sitios en cada área.

Bola preforms (see Figure 2.E) are not recorded in all areas and are infrequent, with the exception of Cardiel Lake basin (Table 1). In Cardiel the high frequency of *bola* preforms stands out, as they are even more numerous than finished *bolas*. This distinguishes the area in the region under study, but also on a broader scale since (Agnolin *et al.* 2019).

All *bola* preforms were found in open-air sites in Cardiel (n:9), Salitroso (n:3) and Cerro Pampa (n:1). Mainly in Cardiel they are limited to specific sectors and associated with sources of raw materials sources (Agnolin *et al*. 2019). In contrast, in Strobel the only preform found was recorded in a basaltic wall.

3.3.2. Raw materials

There are almost no variations between areas regarding the use of raw materials for each artefact (Table 4): Projectile points were manufactured in obsidian followed by siliceous rocks in both neck widths. As previously mentioned, siliceous rocks are naturally available in a wide region, while obsidian only comes from Pampa del Asador. *Bolas* were mostly manufactured in basalt and andesite. There is high availability of both rocks in the region, mainly in Pampa del Asador and the Lake Cardiel (Agnolin *et al.* 2018; Belardi *et al.* 2003; Cassiodoro 2011: 46). It is worth mentioning that the use of local basalt from the basement was identified for *bolas* in some items from Strobel.

On the one hand, preforms show a similar trend than the one identified for finished artefacts: projectile point preforms are primarily of obsidian followed by siliceous rocks; *bolas* preforms are mainly of basalt (Figure 5). These data suggest that obsidian for projectile points was chosen in all areas despite the distance to the source while *bolas* were mainly manufactured in local rocks

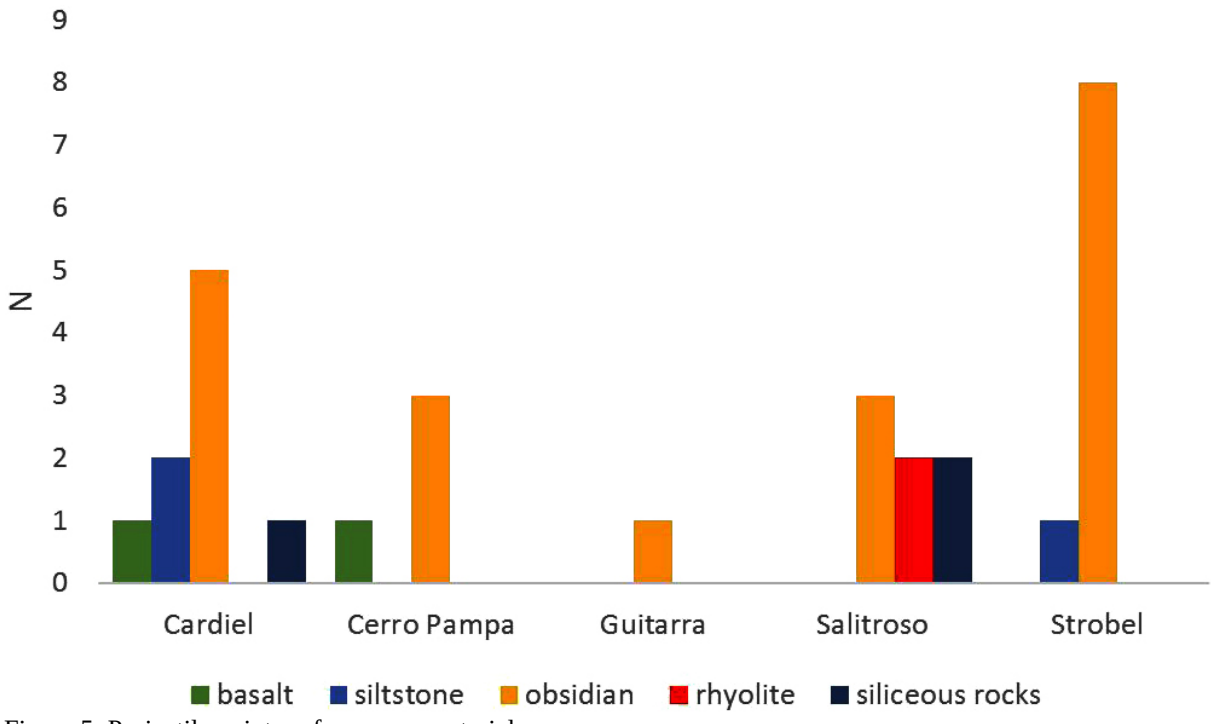

Figure 5: Projectile point preforms raw materials.
Figura 5: Materias primas de preformas de puntas de proyectil.

Table 4: Frequency of raw materials of projectile points and *bolas*. (indet. = indeterminate rocks)
Tabla 4: Frecuencia de materias primas de puntas de proyectil y bolas. (indet. = rocas indeterminadas)

Raw material	Cardiel Lake			Strobel Plateau			Cerro Pampa			Salitroso Lake			Guitarra Plateau		
	Points		*Bolas*	Points		*Bolas*	Points		*Bolas*	Points		*Bolas*	Points		*Bolas*
	<10 mm	≥10 mm		<10 mm	≥10 mm		<10 mm	≥10 mm		<10 mm	≥10 mm		<10 mm	≥10 mm	
Obsidian	8	24	-	21	188	-	18	19	-	34	57	-	2	8	-
Siliceous rocks	2	11	-	9	13	-	4	9	-	8	9	-	-	1	-
Basalt	-	-	4	-	6	13	-	1	-	-	-	-	-	-	-
Siltstone	-	1	-	-	2	-	-	3	-	-	-	-	-	-	-
Rhyolite	1	1	-	-	-	-	-	2	-	-	-	-	-	-	-
Andesite	-	-	-	-	-	5	-	-	-	-	-	6	-	-	-
Sandstone	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Volcanic indet.	-	-	-	-	-	1	-	-	2	-	-	1	-	-	-
Other	1	4	2	-	1	1	-	-	1	-	-	2	-	-	1
Total	**12**	**41**	**6**	**30**	**210**	**20**	**22**	**34**	**3**	**42**	**66**	**10**	**2**	**9**	**1**

Table 5: *Bola* preforms raw materials.
Tabla 5: Materias primas de preformas de bola.

Raw materials	Cardiel Lake	Strobel Plateau	Cerro Pampa	Salitroso Lake	Total
Andesite	-	-	-	1	1
Basalt	8	-	1	-	9
Indet.	1	1	-	2	4
Total	**9**	**1**	**1**	**3**	**14**

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On the other hand, local raw materials were used in areas where lithic resources are available: siltstone and basalt projectile point preforms were recorded in Cardiel, in Cerro Pampa basalt and in Salitroso rhyolite and siliceous rocks. In all cases, these are locally available rocks in each basin, so they would have functioned as secondary options to obsidian.

As for the raw materials of *bola* preforms, they are mostly basalt, followed by indeterminate rocks and one case of andesite (Table 5). In general terms these trends coincide with that of the finished *bolas* (Table 4). The distribution of these artefacts is closely associated with the raw material sources, as discussed in previous works (Agnolin *et al.* 2019).

On the whole, the existence of different manufacturing activities of points and *bolas* can be considered; the latter more linked to the availability of raw materials in the context of residential camps. The former is more homogeneously distributed, mostly using an exotic rock to most of the basins (obsidian from Pampa del Asador) and occurring in a greater variety of sites.

4. Discussion

The distribution and characteristics of the technologies discussed in this work show a series of patterns that allow us to suggest that towards the Late Holocene the adoption and combination of potentially complementary hunting technologies took place. These technologies, with differences in their manufacturing processes, raw materials, transport possibilities, use and potential prey, would have been manufactured and used according to situational differences in a context characterized by environmental variability and fragmentation in the distribution of resources. All things considered, we suggest that the existence of various technological alternatives, and their complementary use, were part of innovative strategies implemented in the new environmental scenario.

Regarding the chronology, projectile points and *bolas* have a greater chronological depth than the one discussed here. In the case of points, different projectile point designs are present before 2500 years B.P., mostly triangular and lanceolate (Aschero 1987; Cassiodoro *et al.* 2020). Based on the record analyzed, their design changed and a form with stem and barbs is adopted at least as from 2300 years B.P. After this, around 1000 B.P., the bow and arrow technology was incorporated, using a new projectile point design. In the case of *bolas*, no significant differences have been observed between designs corresponding to earlier moments and the ones from recent periods (Agnolin *et al.* 2019). Chronologies for small points related to the bow and arrow technology are of interest as their appearance occurs in a context of progressive climate change in the region and the concentration of populations in low basins, in a period of extreme drought (Goñi 2000; 2010: 260; Goñi & Barrientos 2004; Goñi *et al.* 2002). As from this point, the three hunting technologies would have been used in all areas, in a wide diversity of environments.

The simultaneous use of these technologies during the Late Holocene, however, would have changed with the adoption of the horse around the 18th century. As discussed by other authors, and clearly highlighted by travelers' chronicles and ethnohistorical accounts, after the adoption of the horse, the use of *boleadoras* would have been generalized. In this context, bows and arrows and spears with stone points probably fell into disuse (González 1953; Martinic 1995: 208; Outes 1915 see Saletta & Sacchi, 2019). The predominance of *boleadoras*, clearly attested by the chronicles during the 18th, 19th and early 20th centuries, indicates that the changes in the way of life after contact with the Europeans made it less necessary to maintain a diversity of hunting weapons. Future research in this topic will allow us to continue this discussion.

Based on the data presented above, we may suggest different strategies for the manufacture, use and discard of these technologies. Both projectile point types were mostly manufactured in obsidian, even at a considerable distance from the source (more than 100 linear km from the source in the case of Cardiel Lake) and in a wide variety of sites (hunting stands, residential and logistical sites). As for *bolas*, the evidence suggests they were manufactured mainly in specific areas, mostly residential sites in the vicinity of raw material sources, like in Cardiel Lake basin.

According to this, the manufacture of projectile points appears as highly flexible, especially in the case of the smaller ones. They would have been manufactured in a variety of situations, and even preforms (bifaces in the case of bigger points and flakes in the case of smaller ones) would have been transported or manufactured in the same context of use in a short period of time. By contrast, *bolas* were manufactured discontinuously in space, in contexts where time and raw materials were available, and then transported once finished. These differences would be due to the easier transportation of projectile points preforms, as well as a smaller number of steps in their preparation and a lower investment of time in their manufacture. Similar patterns in the manufacture of these artefacts have been detected in other regions of Patagonia (Belardi *et al.* 2021).

Another aspect that likely affected the different production modalities is that of their different useful life. *Bolas* are manufactured in very hard rocks and due to their morphology are highly resistant to fractures. In contrast, projectile points, especially smaller ones, have a higher fracture rate that makes them unusable after just a few uses (Cardillo *et al.* 2021). This gives prominence to *bolas* as a curated artefact, possibly with a longer lifespan than projectile points (Agnolin *et al.* 2019). Therefore, if these artefacts were used in a similar frequency to that of points they would have required less frequent manufacturing activities in time and space, since there would be less need for replacement.

The differences between these systems correspond not only to manufacture, but also to use. Previous works have indicated that findings of isolated *bolas* and points, presumably lost or broken during use, have differences in their distribution. Thus, both *bolas* and points are found mainly in open air settings, but *bolas* are also frequent in the bed of currently dry lagoons (Agnolin *et al.* 2019), in which points are not found (Belardi *et al.* 2005; Flores Coni 2018: 536). Hence, the use of *bolas* technology would have occurred in open spaces and lagoons, possibly using the latter as topographical traps, while arrows and spears would not have used these features in the same way.

On the other hand, if we consider the contexts of point replacement, we find that points were discarded in a variety of site types, both residential and logistical. The two types of points described have similar distributions, although there are some differences. For instance, in the high plateaus both types are frequently found in hunting blinds, although in Strobel smaller points tend to be associated with basaltic walls. In the lower basins, both types of points are widely found in open air sites, mostly residential (Belardi *et al.* 2005; Cassiodoro 2011: 80).

The distribution and characteristics of each weapon technology show differences that imply alternatives offering different possibilities in terms of their potential for replacement, repair and use. For instance, hunting blinds were suitable for the development of hunting strategies with spears, which required approaching the prey (Flores Coni 2018: 536, see Hitchcock & Bleed 1997). In this context, the used points would be repaired and discarded on hunting blinds in their context of use. In this case, both *bolas* and larger points (darts or throwing spears), are technologies that greatly benefit from the proximity of the prey (which is why they usually involve a disadvantage hunting strategy) and are especially oriented to the capture of medium and large prey (Churchill 1993; Vecchi 2010: 90). Contrastingly, the use of bow and arrow would potentially be more flexible, both in terms of hunting strategies, prey

types and topographical contexts (Churchill 1993; Yu 2006). In the study region, arrowheads appear to have been discarded in residential or logistical contexts, but rarely on hunting blinds. In the case of Cerro Pampa, in which they appear associated with hunting blinds, they are contexts with evidence of a diverse use, as residential camps and hunting blinds (Dellepiane & Cassiodoro 2019). This indicates that, although the bow and arrow technology was used in various contexts, the repair of the pieces was preferably done in residential areas. Broken arrowheads were probably transported to camps for repair an activity that was not usually done in the field. The analysis of the distribution of stems and point fragments, combined with the discussion of the distribution and characteristics of the isolated points, will allow future refinement of these proposals.

In the case of *bolas*, their discard during repair activities would have occurred mainly in residential sites, located in open air spaces in the low basins and sheltered by basaltic walls in highlands. On the contrary, its presence in hunting blinds is less frequent; specifically, in the case of Cerro Pampa it occurred in hunting blinds that evidence a greater range of activities carried out in them (Dellepiane & Cassiodoro 2019). This coincides with the evidence of their manufacture, which indicates that the production and replacement of *bolas* would have preferably taken place in multiple activities sites. Likewise, it is worth noting that *bolas* were also found outside sites, possibly related to loss during hunts; there is also evidence of their recycling as grinding stones (Agnolin *et al.* 2019).

Taking this into consideration, weapon systems were part of different organizational strategies which implied using different features of the landscape and different hunting techniques. In the case of spears, they were probably used and repaired in various contexts, though mostly related to hunting of medium and large prey (guanaco and choique) using hunting blinds. Bow and arrow were also used in a variety of contexts and possibly for all the available prey. Flexibility was greater and therefore was probably less related to disadvantage hunting strategies. However, repair and discard of this system was mainly carried out in residential sites. Finally, *bolas* were used in various locations and in a variety of environments, both in open air sites and associated with lagoons, used as topographical traps. They were repaired in residential sites. It is worth noting that although they appear less frequently in the archaeological record, the *bolas* would have had a lower discard rate than points, thus, they were probably used more frequently than what is usually considered.

During the Late Holocene, *bola* and spear technologies were used mainly in relation to disadvantage hunting strategies. Around 900 to 1000 years B.P., in a context of intensifying desiccation and greater fragmentation of the landscape, a hunting technology was incorporated that provided certain facilities for the exploitation of resources and implied fewer requirements in terms of the strategy used: the bow and arrow. However, this incorporation did not imply the abandonment of previous strategies, but there was a complementarity in the use of these artefacts. In this case, the incorporation of the bow and arrow appears as a kind of expansion of the subsistence system, as it provides greater options for obtaining prey. These would not have changed, since it is always about the guanaco and secondarily the *choique* (plus some other species that were scarcely used), but the range of available technologies increased, granting greater flexibility to the obtaining techniques. Likewise, their different demands in terms of raw materials, number of individuals that participate in the hunts, types of prey, rates of loss or fracture, and others, would have given greater flexibility to the Late Holocene groups. Additionally, the various organic raw materials that made up these technologies were different in their origin, availability, replacement potential and manufacturing techniques. These differences would not only be linked to obtaining resources, but could also have played a role in interpersonal conflicts or in aspects such as exchange and territoriality (Goñi *et al.* 2024).

According to what has been presented so far, we can state that, in the face of a highly fluctuating Late Holocene in terms of climate and environments, human behavior has been highly variable. Continuous adaptations and rearrangements are reflected in technological strategies to deal with change. Variability is the key to explaining and understanding the different behaviors necessary to procure resources in all time and space; and that variability translates into technology. Far from setting aside hunting technologies established some 2,500 years ago, the strategies are additive: they add to expand the range and the multiplicity of technological possibilities. Thus, larger stemmed points remain over time, probably together with *bolas*, until they coexist with arrow points for the last thousand years. In different geographies, environments, and types of sites, all these kinds of instruments can be found. So, the answer to this artefactual summation should be sought in the breadth of behaviors in reference to both the various resource offers of each environment in each specific environmental and seasonal condition; as well as the diverse hunting strategies that are imposed according to each specific need. Communal, collective, massive, individual hunts, in small groups, in hunting blinds or in the open, *etc.*; are some of the alternatives, in plateaus and lowlands, either in summer or in winter; all in a context of at least 2500 fluctuating years. Considering this we will get answers to the observations on the data presented here. *Bolas*, larger or smaller projectile points are not mutually exclusive; on the contrary, they can fulfil different functions depending on the circumstances in which the prey procurement requires it. Maintain a technological breadth as a form of additive complementation between instruments; this seems to have been an adequate adaptive strategy of the hunter-gatherer populations of Southern Patagonia to face the challenges of environmental variability.

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Data accessibility statement

The authors confirm that the data supporting the findings of this study are available within the article and in the authors' doctoral theses cited.

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Bolas, puntas de proyectil y tecnologías de caza en Patagonia meridional (Santa Cruz, Argentina) durante el Holoceno tardío

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Resumen:

El centro-oeste de la provincia de Santa Cruz (Patagonia meridional, Argentina) fue ocupado hasta principios del siglo XX por grupos de cazadores-recolectores cuya subsistencia se basó en la caza de un camélido terrestre, el guanaco. Durante los últimos 3000 años, la región se caracterizó por la ocurrencia de procesos de cambio climático y ambiental que implicaron un progresivo desecamiento, con un pico de sequía marcado hacia el 900 A.P. Dichas modificaciones dejaron como resultado un paisaje caracterizado por la aridez y la fragmentación de los recursos en parches. En este contexto cambiante, los grupos locales de cazadores-recolectores utilizaron una variedad de armas para obtener presas: boleadoras, arcos y flechas, y lanzas o dardos.

En este contexto, este trabajo analiza la distribución y cronología de los componentes líticos de estas tecnologías (bolas de piedra y puntas líticas asignadas a flecha y lanza/dardo), incluyendo evidencia de su fabricación (preformas y materias primas). Para esto, consideramos diferentes ambientes (sectores de cuencas bajas y de cuencas altas y mesetas) y diferentes tipos de sitios (sitio a cielo abierto, paredón basáltico, abrigo rocoso, parapeto y entierro). El objetivo es evaluar el papel de estas tecnologías en un contexto de cambios en las estrategias de movilidad y el uso del paisaje. Los resultados sugieren diferencias importantes en el uso y producción de las tecnologías de caza, especialmente en su confección, potencial de reemplazo, transporte y reparación. De este modo, la manufactura de puntas de proyectil habría sido flexible debido a la posibilidad de elaborarlas en pocos minutos sobre formas base transportadas o confeccionadas en el momento, mientras que las bolas de boleadora habrían tenido una manufactura previamente planificada y principalmente realizada en campamentos residenciales junto a fuentes de materias primas. Por otra parte, el uso de estos artefactos y sus técnicas de caza aparece como diferente, señalando que potencialmente eran complementarias. En el caso de las lanzas o dardos, probablemente fueron utilizadas y reparadas en diversos contextos, aunque mayormente relacionados con la caza de presas medianas y grandes (guanaco y choique) utilizando parapetos de caza. El arco y la flecha también se utilizaron en una variedad de contextos y posiblemente para todas las presas disponibles. La flexibilidad de este sistema aparentemente fue mayor y, por lo tanto, probablemente estuvo menos relacionado con las estrategias de caza por desventaja, por lo que no requería del uso de parapetos. Sin embargo, la reparación y descarte de estos instrumentos se llevó a cabo principalmente en sitios residenciales. Finalmente, las boleadoras fueron utilizadas en diversos espacios y en una variedad de ambientes, tanto en sitios al aire libre como asociados a lagunas, utilizadas como trampas topográficas. Fueron reparados en sitios residenciales.

Nuestro argumento principal sugiere que los cazadores-recolectores diversificaron sus tecnologías, específicamente aquellas utilizadas para la obtención de presas, en un contexto de fragmentación del paisaje y de los recursos. Se produjo, por tanto, un uso complementario pero diferencial de las tecnologías y no un proceso de adopción y abandono.

Palabras clave: bolas; arco y flecha; lanza; dardo; Holoceno tardío, cambio climático