Human Dispersal in the Atlantic Slope of Patagonia and the Role of Lithic Availability

Nora V. Franco, Luis A. Borrero & Gustavo F. Lucero

To cite this article: Nora V. Franco, Luis A. Borrero & Gustavo F. Lucero (2019): Human Dispersal in the Atlantic Slope of Patagonia and the Role of Lithic Availability, PaleoAmerica, DOI: 10.1080/20555563.2019.1582128

To link to this article: https://doi.org/10.1080/20555563.2019.1582128

Published online: 05 Mar 2019.

Submit your article to this journal

Article views: 11

View Crossmark data
Human Dispersal in the Atlantic Slope of Patagonia and the Role of Lithic Availability

Nora V. Franco, Luis A. Borrero, and Gustavo F. Lucero

CONICET-IMHICIHU, Universidad de Buenos Aires, FFyL, Depto Ciencias Antropológicas, Buenos Aires, Argentina; Laboratorio de Paleocología Humana, Facultad de Ciencias Exactas y Naturales, Universidad Nacional de Cuyo, Mendoza, Argentina

ABSTRACT
The purpose of this paper is to understand the role of different resources in the human ranking of habitats during the peopling of the Atlantic slope of Central-South Patagonia, as well as the technological strategies used during early human dispersal. We studied the distribution of early sites in the Deseado Massif, where there is a relatively high concentration of evidence of early human activity. We analyzed published information related to site chronology and distribution, presence/absence of hearths, raw-material provenance, the presence of bifacial artifacts and reduction activities, the location of corridors, and least-cost paths among sites. Results show that water would have been the most important resource in selecting locations. The availability of high-quality rocks would have been an asset, which also helped to generate a highly visible archaeological record in which bifaces were important. These resources were probably exploited using a multidirectional half-radius pattern of movements, basically restricted to the eastern margin of Massif.

KEYWORDS
Patagonia; initial human dispersal; lithic resources

1. Introduction
According to current knowledge, the process of peopling of Patagonia was one of a slow fill-in of empty spaces (Borrero 1989–90, 1994–95). The model contemplates the human exploration of new lands, sometimes followed by colonization. The known early sites in the Atlantic slope, which are a result of this process, are not evenly distributed in the space. Although research biases and formation processes can be at least partially responsible for this distribution, it is also true that hunter-gatherers rarely make use of the whole geographical space with the same intensity (Borrero 1989–90). For that reason, the archaeological evidence for the exploration of some places could be relatively late in comparison to that from the older sites of the region. Early human populations probably used different strategies for dispersal into new land, with water probably having an important role in these low precipitation environments (e.g., Pérez et al. 2016; Veth 2005). Eastern Patagonia has very few annual repositories of drinking water between the river basins (Borrero 2005; Mayr et al. 2005; Miotti and Salemme 2004); accordingly rivers could have had an important role during these initial movements.

Exploration refers to the initial radiation of humans to new empty land. We think that during initial exploration humans probably moved along natural routes, and that non-optimal localities were used. According to Borrero (1989–90), a low density of sites can be expected, as well as low occupation redundancy, leading to low expectations for the recovery of relevant archaeological sites (Borrero 1989, 1994–95). A more recurrent use of sites located in optimal locations is expected during land colonization, which is the phase of settling-in, when a region begins to be fully used and a relatively good knowledge of the distribution of resources and associated ecological cycles exists, as well as clusters of sites with good visibility and stratigraphic resolution (Borrero 1989–90, 1994–95).

There are many possible reasons for exploration and eventual colonization of a region, including among others the gradual extension of hunting ranges, the fission of bands, or the search for high-quality raw-material sources (Anderson and Gillam 2000). The speed of this dispersal is probably related to the degree of environmental homogeneity between the previously known areas and the new lands (i.e., Kelly 2003a). Most of the evidence for this process can be elusive, especially taking into account the low human demography expected for that time, the difficulty of finding early open-air occupations, and the formation processes involved.

During the early exploration and colonization of Patagonia, environmental conditions were different from...
those existing today. By ca. 16,000 cal yr BP, the retreat of the Andean glaciers was taking place (Glasser et al. 2012). Human southern expansion probably took place at a time when the Atlantic coast extended several km to the east, increasing continental conditions (Ponce, Borromei, and Rabassa 2011). At this time, the Antarctic Cold Reversal (ACR), which lasted from 14,500 to 12,700 cal yr BP (Blunier et al. 1997; Moreno et al. 2012), was taking place, followed by the Younger Dryas (YD), which in the Southern Hemisphere was a warmer period that lasted from 12,700 to 11,500 cal yr BP. A maximum postglacial temperature was reached around 11,500 cal yr BP (Bianchi and Gersonde 2004). The river basins were probably established by that time (McCulloch et al. 1997).

It was recently proposed that the human presence in the Pacific slope of South America at ca. 42° S started at least sometime near 18,000 cal yr BP (Dillehay et al. 2015). However, most of the replicated dates in the Atlantic slope are not earlier than 13,000 cal yr BP (e.g., Brook et al. 2015; Franco et al. 2010; Miotti, Salémme, and Rabassa 2003; Paunero 2000; Paunero et al. 2007; Steele and Politis 2009). Since this chronological signal is recorded at several places in Patagonia, it appears safe to say that it is the time when the process of colonization was consolidated in many Patagonian regions. Accordingly, older dates can be expected for the first human entries to those regions.

The purpose of this paper is to investigate the role of different resources, including lithics, in the ranking of habitats during the peopling of the Atlantic slope of Central-South Patagonia, as well as the technological lithic strategies used during initial human colonization. This process involved different kinds of environments, with humans probably using least-cost paths and settling in rich resource areas.

2. The study area

Patagonia is composed of a series of progressively lower plateaus extending eastward from the Andes (Soriano 1983), which are crossed by rivers that flow with a general West–East direction from the Andes to the Atlantic Ocean. The climate is arid to semi-arid, with mean annual temperatures that range between 12 and 3°C (Paruelo et al. 1998; Soriano 1983). There is a very steep gradient of mean annual precipitation resulting from the presence of the Andes. It decreases towards the east, from around 1000 mm in the Andes foothills to less than 200 mm in the central plateau (Soriano 1983). A deciduous forest of Nothofagus antarctica and Nothofagus pumilio is present along the eastern slopes of the Andes, while Extra-Andean Patagonia is an area dominated by semi-arid grass and shrub steppes, with dwarf-shrub communities in the drier areas of the central plateau, adapted to cope with severe water deficits (León et al. 1998; Roig 1998).

The Deseado Massif, where our analysis is centered, is a morphostructural region shaped by volcanic activity during the Jurassic (De Giusto, Di Persia, and Pezzi 1980). The Deseado Massif is variable in geology, geomorphology and spatial and temporal availability of water. However, it has an important characteristic, which is the availability of high-quality siliceous rocks, as has been recognized by different researchers (Cattaneo 2000, 2004; Franco et al. 2015; Hermo 2008; Skarbun 2009). Those rocks can be obtained from the Chon Aike, La Matilde, Bajo Grande, and Baqueró formations, as well as from siliceous infills (e.g., Echeveste 2005; Panza and Haller 2002; Panza and Marin 1998; Zubía 1998). The process of silification is more important in the north than in the south of the Massif. Pampa del Asador, located west of the Massif, is the most important source of black obsidian (Stern 2000). Other secondary sources have been located toward the east, one of them more than 170 km away, at only 10 km south of the Deseado Massif (Franco et al. 2017). More recently, Nami and coauthors, on the basis of the presence of isolated pebbles of obsidian along the coast, have suggested the possibility that obsidian nodules from Pampa del Asador were transported and deposited among the Patagonian gravels (Nami et al. 2018). However, this must be analyzed in further detail since they have not been reported for the Deseado Massif and nearby locations. Some of the samples reported by Nami and coauthors were obtained at archaeological sites (Punta Medanos), and only very general information was offered for the provenience of the rest of the samples.

3. Methodology

For the purpose of this paper, we studied the distribution of early sites in the Atlantic slope of Patagonia. Due to the relatively high concentration of sites in the Deseado Massif, we analyzed published information generated by different research teams related to site chronology, distribution, discard rates, presence/absence of hearths, raw-material provenance, presence of bifacial reduction activities, the location of corridors between cores, and least-cost paths among sites. As some of the sites are still being excavated, information about the excavated area at each site was included.

We consider that the presence and size of the hearths provide clues about the length of the human stay, especially if there was no cleaning of the hearths, and the sites were not continuously occupied, as it seems to
have been the case (e.g., Brook et al. 2015; Franco et al. 2010; Paunero et al. 2007). The utilization of bifaces as part of a curated strategy for peopling of new environments has been suggested, not only in North America but also in South America (Borrero and Franco 1997; Franco 2004, 2012; Kelly 1988; Meltzer 2009; Waters and Jennings 2011). During the colonization of new environments, the presence of bifaces can be related to the possibility of using them for different tasks and/or as cores for producing large and usable flakes (Kelly 1988), as well as to solve environmental incongruencies (Meltzer 2009). During the human colonization of spaces, a better knowledge of the local resources in comparison to the times of initial exploration can be expected. In addition, a less intense use of immediately available rocks can be expected, except when high-quality rocks are involved (Borrero and Franco 1997; Franco 2012). Rock sources available in highly specific places are now expected to be used, increasing the percentage of locally available high-quality rocks, and creating a better relationship between the task at hand and the rock characteristics.

In the case of the Deseado Massif, there are different definitions of local rocks. For example, Skarbun et al. (2007) consider as local only rocks that can be obtained at distances of less than 20 km, while those obtained beyond that distance are considered exotic. In addition, rocks which can be obtained within the same landscape unit (Skarbun et al. 2007) where the site is located, are considered as immediately available. On the other hand, following Meltzer (1989) and relevant ethno-graphic data, Franco (2004) considers rocks obtained up to distances of 40 km as local, dividing them between those that can be obtained up to distances of 10 km (close local) and those that are more distant (distant local) (Civalero and Franco 2003). The concept of immediate vicinity, originally developed by Goodyear (1989), is also used by these authors, who differentiate these rocks from those available at greater distances.

From a biogeographical perspective, GIS was used to model the landscape on the basis of actualistic information and as a tool to analyze connectivity between cores and archaeological sites. Humans move and make decisions along the landscape where they are settled (e.g., Bird and O’Connell 2006; Foley 1981). Modeling of human routes using GIS – based on topography – has been applied in different South American environments (e.g., Barberena et al. 2017; Cortegoso et al. 2016; Lucero, Marsh, and Castro 2014; Miotti and Magnin 2012; Rademaker, Reid, and Bromley 2012; Tripcevich 2008).

The concept of distance is basic to the understanding of spatial relationships. Movements in landscape imply a variable cost expressed in distance, time, or energy. Raster layers that contain a cost variable are called friction surface. In this study, the spatial analyses are based on making an anisotropic cost surface from the ArcGIS Path Distance function. The anisotropic cost relates energy consumed with the degree of slope, taking into account that energy wasted varies according to the degree of slope, in an irregular and non-constant way (Conolly and Lake 2009; López Romero 2005).

Taking into account the ecological basis of Borrero’s model for the human peopling of Patagonia (Borrero 2011), we selected ecological cores in the steppe and forest, arbitrarily located in places with water availability, e.g., close to rivers. This makes sense in terms of the known history of human occupation of Patagonia (Pérez et al. 2016) and also derives from considering water a critical resource.

With reference to water, cores were set up close to rivers, in the Southeast of the Deseado Massif, and close to the western forest. In the case of the southern massif, palynological studies suggest the existence of more humid conditions during early occupations of this environment (Brook et al. 2015; Mancini, Franco, and Brook 2012). In a previous paper (Francesca et al. 2018), the drainage network during wetter periods was modeled on the basis of topography, using GIS, flow direction, and accumulation analysis (e.g., Li 2014; Maidment 2002; Merwade 2012; Wheatley and Gillings 2002). This procedure suggested the existence of water availability to the southeast of the Deseado Massif, and because of this reason, a core was set up in this area.

Natural routes of less resistance and main geographic vectors related to mobility were modeled using GIS (i.e., Cortegoso et al. 2016). Natural corridors were modeled between ecological cores in places with permanent or temporal water, using LinkageMapper to model this connectivity among ecological cores (McRae et al. 2008; McRae and Kavanagh 2011). The location of archaeological sites was related to these corridors and also to geological formations containing high-quality siliceous rocks. In a second step, Least Cost Path analysis (LCP) was used to model connectivity among archaeological sites (i.e., Lucero, Marsh, and Castro 2014; Rademaker, Reid, and Bromley 2012), which were compared with the location of corridors. In both analyses, each cell has a resistance value related to the difficulty of moving across the cell, which is related to the topographic characteristics of the environment modeled from digital elevation models (DEM) (Tachikawa et al. 2011). Both analyses process the resistance raster and the cores map following different steps: identify adjacent (neighboring) core areas, construct a network of core areas using adjacency and distance data, and calculate cost-
weighted distances and least-cost paths (McRae and Kavanagh 2011). The distance values between archaeological sites in the Deseado Massif, water, and lithic resources were extracted using the Euclidean Distance tool. As most of these sites and resources are located at altitudes of less than 400 masl, we consider that, in this case, distance is the most important variable. Because of this reason, isotropic analyses were carried out between sites and water resources, and between sites and geological formations with raw materials of excellent quality.

4. Results

4.1. Chronology, length of occupation, and artifact characteristics

In the Atlantic slope of Patagonia, most of the sites with dates earlier than 10,500 cal yr BP come from rockshelters and caves (e.g., Brook et al. 2015; Franco et al. 2010; Martin et al. 2015; Massone and Prieto 2004; Paunero 2000, 2003a, 2003b; Paunero et al. 2007; Figure 1). These sites, some of which probably correspond to the early exploration and colonization of this space, have a highly discontinuous distribution. As can be seen in Figure 1, most of them are located in the Deseado Massif.

In this paper, we focus our analysis on the characteristics and location of sites with replicated early dates in the massif (Brook et al. 2015; Franco et al. 2010; Miotti, Salemme, and Rabassa 2003; Paunero 2000, 2003a, 2003b; Steele and Politis 2009). Although efforts have been reported to find open air sites (Franco pers. obs.; Paunero et al. 2007, 2015), all the discovered early sites are located in small rockshelters and/or caves (Figure 2). However, preforms and fragments of projectile points that can be attributed to early periods due to their technological or morphological characteristics have been found in open-air spaces, indicating the complementary utilization of these locations (Brook et al. 2015; Franco and Vetrisano forthcoming). It is worth mentioning that, even in Patagonia, there is great variability within the so-called Fishtail projectile points (e.g., Bird 1969; Castiñeira et al. 2012; Hermo and Terranova 2012; Hermo, Terranova, and Miotti 2015; Jackson 2002, 2004; Massone and Prieto 2004; Miotti, Hermo, and Terranova 2010; Nami 2003), suggesting that it probably was more than an early design used by hunter-gatherers, as was suggested for South America as a whole (e.g., Flegenheimer, Miotti, and Mazzia 2013; Franco and Vetrisano forthcoming; Hermo, Terranova, and Miotti 2015; Massone and Prieto 2004; Nami 2014; Suárez 2010). Some of the recorded variation of these early designs can be attributed to the existence of resharpening processes (e.g., Castiñeira et al. 2012; Hermo, Terranova, and Miotti 2015). The function of the miniatures identified in a few sites is unknown. Politis, Messineo, and Kaufmann (2004) have attributed them to learning activities involving kids. However, Flegenheimer and coauthors, based on their minimum in labor investment but the existence of some morphological similarities, believe they have some social significance related to hunting activities (Flegenheimer and Weitzel 2017; Flegenheimer, Weitzel, and Mazzia 2015). The dates obtained for these projectile points in Pampa and Patagonia are older than 10,200 cal yr BP (e.g., Flegenheimer, Miotti, and Mazzia 2013; Martin et al. 2015; Massone and Prieto 2004; Nami 1987). The early Holocene radiocarbon date reported for Pali-Aike cannot be used since it was made on a pooled sample of Mylodon, Hippidion, and camelid bones (Bird 1988).

Table 1 presents early sites with replicated ages earlier than 10,500 cal yr BP in the Deseado Massif. Figure 3 shows their distribution.

The earliest date obtained corresponds to Cerro Tres Tetas, cave 1 (Paunero 2000; Paunero 2003a; Steele and Politis 2009). With the exception of Piedra Museo and Cueva Túnel, there is a decrease in radiocarbon dates from North to South, suggesting a N-S general peopling direction (Table 1, Figure 3), which is in accordance with general knowledge (e.g., Borrero 1989–90, 1994–95; Miotti and Salemme 2004). According to paleoenvironmental information, by the time of the early peopling of Piedra Museo, a shrub steppe was present in the area, which changed into a grass steppe by ca. 12,800 cal yr BP (Borromei 2003). Meanwhile, to the south, in Casa del Minero, a grass steppe was present during the initial peopling of the area, with a change to a shrub steppe at ca. 12,000 cal yr BP (De Porras 2010). More to the south, early human occupations took place under more humid conditions (e.g., Brook et al. 2013, 2015; Mancini, Franco, and Brook 2012; Mancini, Franco, and Brook 2013).

There is similarity of human dates obtained at Piedra Museo, Casa del Minero, and La Gruta 1, all of them located very close to the border of the Deseado Massif (Figure 3). Fishtail or projectile points with early designs were recovered at these sites (i.e., Piedra Museo) or on the surface in nearby places (La Gruta and neighboring localities Laguna Escondida and El Engañó; cf. Vetrisano and Franco forthcoming). In the case of Piedra Museo, a deposit containing two Fishtail projectile points was dated between 11,935 and 12,436 cal yr BP (Miotti, Salemme, and Rabassa 2003).

Discard rates at these sites were calculated taking into account the quantity of artifacts and tools recovered within dated deposits, divided by the difference between
the maximum and minimum mean dates obtained at the deposit where they were recovered, and then divided by the total excavated surface. In general, there are low artifact discard rates, which range from 0.0001 to 0.21 artifacts per year (Table 2), although it must be kept in mind that some of these early sites are still in the excavation process (e.g., La Gruta 1). The highest rate corresponds to Casa del Minero 1. Hearths or charcoal concentrations are present in these sites. In addition, most of these sites have been characterized as logistic ones.

There is variability in the frequency of utilization of local rocks, which is probably related to site function, length of stay, and availability of high-quality rock, as explained in detail below.

Local rocks, although not immediately available (sensu Meltzer 1989), were used in most of the sites. Local high-quality rocks (silicified wood, chalcedony, and opals) are the most frequently used in the deepest deposit of Piedra Museo (unit 6), with an increase in the use of immediately available rocks (Civalero and Franco 2003; Meltzer 1989) for the overlying unit 4/5 (Miotti and Cattaneo 2003). Also, rocks are mostly local in the case of Casa del Minero 1, located in an area with abundant, excellent high-quality rocks.
In this case, higher discard rates seem to suggest longer stays at the site. Artifacts recovered at La Gruta 1 seem to have been manufactured from distant local raw materials (i.e., distances between 10 and 40 km according to Civalero and Franco 2003). In the case of Cueva Túnel, non-local translucent opal was the rock most commonly used, and the transport of cores was identified (Skarbun 2012). High-quality local siliceous rocks were recovered as debitage, being tools probably transported to other areas (Skarbun 2012). In general, transport of rocks from and to different places was taking place, with a high frequency of local rocks, mostly those not immediately available. The clear exception is Casa del Minero, located in an area where high-quality rocks are abundant, and where longer stays probably took place.

The presence of knives and side scrapers from bifacial cores as well as the use of bifacial flakes has been recorded in the deepest deposit of Piedra Museo – unit 6 – and has been related to the utilization of generalized tools (Miotti and Cattaneo 2003). A change from this strategy to the use of standardized tools from flakes coming from cores has been identified in unit 4/5, where also two fragmented fishtail projectile points have been recovered (Miotti and Cattaneo 2003). A bifacial preform and a bifacial notch were identified at Cerro Tres Tetas, a functionally specific site (Paunero 2000). A high percentage of prepared percussion platforms is also present at the site. The presence of a bifacial preform was identified in the deepest deposit at Casa del Minero. There are last-stage bifacial reduction flakes both at Casa del Minero 1 and La Gruta 1. In the case of Piedra Museo’s deepest deposit (Unit 6) and La Gruta 1, raw materials used for bifacial reduction are probably local (Franco et al. 2015; Miotti and Cattaneo 2003). In the case of La Gruta 1, they are distant local, probably coming from distances up to 25 km (Franco and Vetrisano, pers. obs.). Jennings, Pevny, and Dickens (2010) experimentally demonstrated that there are not significant differences in core efficiency between bifacial, prismatic
Table 1 Archaeological sites with calibrated dates older than 10,500 cal yr BP.

| Archaeological site       | Lab code | Radiocarbon date (BP) | Calibrated date (cal yr BP) | Unit | Material                                    | Reference                        |
|---------------------------|----------|-----------------------|----------------------------|------|---------------------------------------------|----------------------------------|
| Piedra Museo (a)          | AA-27950 | 11,000 ± 65           | 12,713–12,994               | Unit 6; bottom | Charcoal                                      | Miotti, Salemme, and Rabassa (2003) |
| Piedra Museo (b)          | Ox-8528  | 10,925 ± 65           | 12,685–12,928               | Unit 6; bottom | Charcoal; same bone as (c)                   | Miotti, Salemme, and Rabassa (2003) |
| Piedra Museo (c)          | OxA-15870| 10,675 ± 55           | 12,542–12,705               | Unit 6, bottom | Bone (Hipposidium salidasi); same bone as (b) | Steele and Politis (2009)          |
| Piedra Museo (d)          | OxA-9249 | 10,470 ± 65           | 12,033–12,448               | Unit 5, bottom | Charcoal; same as sample (g)                 | Miotti, Salemme, and Rabassa (2003) |
| Piedra Museo (e)          | Gra-9837 | 10,470 ± 60           | 12,039–12,443               | Unit 6; bottom | Charcoal                                      | Miotti, Salemme, and Rabassa (2003) |
| Piedra Museo (f)          | AA-8428  | 10,400 ± 80           | 11,935–12,436               | Unit 5, middle | Bone (Camelidae)                             | Miotti, Salemme, and Rabassa (2003) |
| Piedra Museo (g)          | AA-39367 | 10,400 ± 79           | 11,935–12,435               | Unit 6, bottom | Charcoal; same as sample (d)                 | Steele and Politis (2009)          |
| Piedra Museo (h)          | OxA-8527 | 10,390 ± 70           | 11,938–12,430               | Unit 6, middle | Bone (Lama guanicoe)                        | Miotti, Salemme, and Rabassa (2003) |
| Piedra Museo (i)          | AA-9507  | 10,100 ± 110          | 11,265–11,965               | Unit 6   | Charcoal; same as sample (d)                 | Steele and Politis (2009)          |
| Piedra Museo (j)          | AA-39362 | 9952 ± 97             | 11,176–11,755               | Unit 6    | Bone (Hipposidium salidasi)                 | Steele and Politis (2009)          |
| Piedra Museo (k)          | OxA-9509 | 9950 ± 75             | 11,195–11,628               | Unit 6 or 5/6 | Charcoal                                    | Steele and Politis (2009)          |
| Piedra Museo (l)          | LP-859   | 9710 ± 105            | 10,708–11,246               | Unit 4 (bottom) | Charcoal; same as samples (e) and (f) (Steele and Politis 2009). | Miotti, Salemme, and Rabassa (2003) |
| Casa del Minero (a)       | AA-22233 | 11,100 ± 150          | 12,701–13,188               | Unit 5, lower | Charcoal; same as sample (d)                 | Paunero (2003a)                   |
| Casa del Minero (b)       | AA-39368 | 11,015 ± 66           | 12,717–13,005               | Unit 5, lower | Charcoal; same as sample (b)                 | Paunero (2003a)                   |
| Casa del Minero (c)       | OxA-9244 | 10,915 ± 65           | 12,680–12,914               | Unit 5, lower | Charcoal; same as samples (a) and (f)        | Paunero (2003a)                   |
| Casa del Minero (d)       | AA-39366 | 10,853 ± 70           | 12,645–12,831               | Unit 5, lower | Charcoal; same as samples (a) and (e)        | Paunero (2003a)                   |
| Casa del Minero (e)       | LP-781   | 10,850 ± 150          | 12,427–13,048               | Unit 5, lower | No data                                      | Paunero (2003a)                   |
| Casa del Minero (f)       | LP-800   | 10,260 ± 110          | 11,591–12,404               | Unit 5, upper | Charcoal (Steele and Politis 2009); same as sample (b) | Paunero (2003a) |
| Casa del Minero (g)       | AA-82496 | 10,510 ± 110          | 12,026–12,650               | Unit 8   | Bone (Camelidae, De Porras 2010)             | Paunero et al. (2015)             |
| Casa del Minero (h)       | LP-1965  | 10,420 ± 180          | 11,601–12,690               | Unit 8   | Bone (Lama sp., De Porras 2010)              | Paunero (2009)                    |
| Casa del Minero (i)       | AA-71147 | 10,408 ± 59           | 11,989–12,425               | Unit 10  | Charcoal (De Porras 2010)                    | Paunero et al. (2015); Skarbun (2009) |
| Casa del Minero (j)       | AA-71148 | 10,400 ± 100          | 11,819–12,450               | Unit 10  | Bone (Hipposidium salidasi, De Porras 2010) | Paunero et al. (2015); Skarbun (2009) |
| La Gruta 1 (a)            | AA-37207 | 10,999 ± 55           | 12,716–12,980               | Unit 4   | Probably charcoal                            | Paunero et al. (2007)             |
| La Gruta 1 (b)            | AA-37208 | 10,967 ± 53           | 12,704–12,952               | Unit 4   | Probably charcoal                            | Paunero et al. (2007)             |
| La Gruta 1 (c)            | AA-45705 | 10,250 ± 110          | 11,401–12,299               | Unit 3c  | No data                                      | Paunero et al. (2007)             |
| La Gruta 1 (d)            | AA-84224 | 10,845 ± 61           | 12,650–12,801               | Unit A   | Charcoal                                     | Franco et al. (2010)              |
| La Gruta 1 (e)            | AA-84223 | 10,840 ± 62           | 12,650–12,801               | Unit A   | Charcoal                                     | Franco et al. (2010)              |
| La Gruta 1 (f)            | AA-76792 | 10,656 ± 54           | 12,538–12,692               | Unit A   | Charcoal                                     | Franco et al. (2010)              |
| La Gruta 1 (g)            | AA-84225 | 10,477 ± 56           | 12,049–12,444               | Unit A   | Charcoal                                     | Franco et al. (2010)              |

blade, and wedge-shaped blade core reduction, although the efficiency of bifacial and blade cores decreased with initial core weight. However, bifaces are versatile tools (Nelson 1991), and their utility can be linked not only to their potential to be used as cores, but also to their capacity to be shaped into different kinds of tools, as the already mentioned findings from Piedra Museo Unit 6 suggests.

Black obsidian is present in only two sites: La Gruta 1 (Franco et al. 2010, 2015) and Cerro Tres Tetas (Paunero 2003a). Both sites are located more than 100 km from the Pampa del Asador source (Belardi et al. 2006; Cueto, Frank, and Skarbun 2018; Espinosa and Góñi 1999; Stern 2000). The distance from Tres Tetas to the Pampa del Asador and 17 de Marzo sources is almost the same; however, La Gruta 1 is located only 12 km from the latter (Franco et al. 2017). Although Cueto, Frank, and Skarbun (2018) attribute a small obsidian artifact (less than 2 mm in length) from Cerro Tres Tetas to Pampa del Asador, they did not consider into their analysis the alternative source of 17 de Marzo, with a similar composition (Franco et al. 2017). In fact, it can come from any of the sources.

In general we can say that the occupational penecontemporaneity, along with the very low artifact discard rates, suggest the presence of small and highly mobile groups, with very short stays at each site (Brook et al. 2015; Franco et al. 2010; see also Paunero 2009). At
this time, bifaces were part of the transported tool kit (Borrero and Franco 1997). As mentioned, bifaces can be used in different ways, as cores or tools (see Goodyear 1989), or as long-life use tools (Kelly 1988). Transporting bifaces can be useful when the location of the resources is not known and their versatility (sensu Nelson 1991) would be important for highly-mobile hunter-gatherers. Also, they serve to solve inconsistencies in the distribution of resources (Meltzer 2009). In the case of the Deseado Massif, high-quality rocks are frequent, although they are not evenly distributed (Franco et al. 2015; Hermo 2008), and the need to have raw materials of excellent quality, along with transportability (sensu Nelson 1991), may be the reason for their transport. We totally agree with different researchers (Brantingham et al. 2000; Eren et al. 2014) that up to a limit, raw-

**Figure 3** Dates prior to 10,500 cal yr BP in the Deseado Massif. Dates are arranged in chronological order, from the oldest to the youngest.

**Table 2** Main variables analyzed and distance to probable water sources. Artifact rates are calculated on the basis of Cattaneo (2005), Franco et al. (2010, 2015), Miotti (1992), Paunero (2003a, 2003b), Skarbun (2009), Skarbun et al. (2015).

| Site               | Discard rate per m² per year | Hearths and charcoal concentrations | Black obsidian presence | Excavated surface (m²) | Nearest probable water source                                                                 |
|--------------------|-----------------------------|-------------------------------------|-------------------------|------------------------|-----------------------------------------------------------------------------------------------|
| Cerro Tres Tetas   | 0.046                       | Yes                                 | Yes (Paunero 2003a)     | 12.25 (Paunero 2000)   | 110 m to a current water source                                                               |
| Cueva Túnel        | 0.0027                      | Yes                                 | No                      | 17.25 (Skarbun et al. 2015) | 75 m from a lower area that collects water                                                     |
| Casa del Minero 1, units 4 and 3c | 0.0036                     | Yes                                 | No                      | 15.32 (Paunero et al. 2007) | 29 m to a temporary gully (5.83 m above it) and 1.360 m to a big temporary lagoon (Paunero et al. 2007) |
| Piedra Museo U6    | 0.00181                     | Yes                                 | No                      | Around 50 (Miotti, Salemme, and Rabassa 2003) | Close to a gully, which flows into a big lagoon, currently without water (Miotti, Salemme, and Rabassa 2003) |
| Piedra Museo U4/S  | 0.00020                     | Yes                                 | No                      | Around 50 (Miotti, Salemme, and Rabassa 2003) | Close to a gully, which flows into a big lagoon, currently without water (Miotti, Salemme, and Rabassa 2003) |
| La Gruta 1         | 0.06                        | Yes                                 | Yes (Franco et al. 2010) | 1 (Brook et al. 2015; Franco et al. 2010) | Located by a current temporary pond                                                             |
material differences are not a factor explaining tool morphology. However, as different flintknappers have pointed out, there is an effect of the quality of raw materials in the flintknapping process (for example Callahan 1979; Nami 1986). There are also implications for differential transport, resharpening, or discard distances related to this quality variation (i.e., Cortegoso 2008; Goodyear 1989; Smith 2015; Tomasso and Pourraz 2016), and for those reasons we believe that each case should be analyzed in detail. The quality of the raw material, sometimes improved through heat-treatment, seems to have been important during early colonization times (e.g., Collins 1999; Goodyear 1989; Meltzer 2009).

In the case of our study area, high-quality siliceous rocks of unknown origin have been recovered in two caches (Franco et al. 2011, 2018). The percentage of local raw material probably varies according to the function and length of the stay at each site, as well as to the existence of high-quality raw materials in the area where the sites are located. In our case, siliceous raw materials probably coming from nearby places are introduced into different sites. High quantities of excellent siliceous rocks immediately available were recovered at Casa del Minero, and transport of raw materials from this site to other places was also identified. Bifacial artifacts have been recovered in different sites, and in some cases they have been used as blanks for different tools. With reference to black obsidian, in the case of La Gruta 1 the secondary nearby source of 17 de Marzo (located 12 km from La Gruta; Franco et al. 2017) was probably used, obtained during regular hunter-gatherer activities. It should be mentioned that, due to the presence of this distal obsidian secondary source, the presence of other secondary sources of this obsidian cannot be discarded (Franco et al. 2017).

Remarkable is the frequency of early sites in the Deseado Massif, as has already been pointed out (i.e., Borrero 1989–90; Miotti and Cattaneo 2003; Miotti and Salemme 2004; Paunero 2009; Salemme and Miotti 2008). Miotti and Salemme (2004) attribute this

---

**Figure 4** Corridors between ecological cores © with probable water sources before 10,500 cal yr BP and geological formations with high-quality siliceous rocks in the Deseado Massif. Dots indicate secondary black obsidian sources.
frequency to a restricted mobility related to resource concentration. We are going to analyze the case in greater depth.

4.2. Site location

As mentioned, to analyze site locations, corridors were set up between ecological cores, which were located in places with permanent and semi-permanent water supplies (rivers and places close to the forest). In addition, in the southern Deseado Massif early human presence occurred during a more humid period. Because of this reason, cores were set up where simulation models indicate the presence of streams. In particular, because of the results of the simulation models and the general slope of the surface (see Franco et al. 2018), two core areas were set up at the eastern and southern side of the Deseado Massif. Figure 4 indicates the location of these cores as well as the geological formations containing siliceous rocks of excellent quality, and corridors between them. It is worth mentioning that most of these sites are located close to paleo-lagoons, ponds, or streams that do not have water today or that only have it occasionally (Table 2). Where human occupations occurred during a more humid period (for example, in the southern Deseado Massif), it is probable that they had water.

As can be seen, there is a fairly good relationship between sites with early chronologies and these corridors, as well as between ecological corridors and LCP (Figure 5), suggesting that water and associated resources were important, as it has been already suggested (among others, Borrero 1994–95, 2005; Miotti and Salemme 2004). The exceptions are Cerro Tres Tetas – which is the oldest known archaeological site – and Cueva Túnel, around 45 and 14 km away from the corridors, respectively. Although dates for water sources have still not been obtained, Cerro Tres Tetas is located around 110 m from a modern spring, and Cueva Túnel is around 75 m from a low area which collects water from several

![Figure 5](image.png) Early sites in the Deseado Massif and least-cost paths between them. Corridors among cores as well as rock formations with high-quality siliceous rocks present in the area are also indicated.
small canyons (see Table 2). It is interesting to note that the 17 de Marzo secondary obsidian source is located within one of these natural corridors, reinforcing the possibility of human provisioning of obsidian during regular activities.

Excellent rock quality may also have attracted early hunter-gatherers, as has also been suggested for North America, although there is still not agreement about the existence of special provisioning trips (e.g., Ellis 2011; Goodyear 1989; Meltzer 2009). To evaluate their importance in Patagonia, we analyzed the distribution of sites in relation to high-quality siliceous rocks at a regional scale. In this sense, it is worth mentioning that there are variations in high-quality siliceous rocks at smaller scales (Cattaneo 2004; Franco et al. 2015; Hermo 2008; Miotti and Cattaneo 2003). These scales, however, are within the proposed home-ranges of terrestrial hunter-gatherers at these latitudes (Binford 2001; Kelly 1995).

It can be seen that early archaeological sites are located in places with drinking water, but also along the border of the Deseado Massif, where high-quality rocks can be obtained (Figure 5). It should be mentioned that until now, early archaeological sites were found neither close to the Atlantic Ocean nor in the interior of the Deseado Massif. In our case, while corridors (grey gradient) border the Deseado Massif, least-cost paths (in white) suggest movements into the interior (see details in Figure 5). The lack of differences in resources between the massif and nearby spaces, with the exception of high-quality siliceous rocks, suggests that these regular activities are probably related to raw material provisioning.

There is minimal variation in Euclidean distance data between archaeological sites and resources, which is statistically shown in Figure 6. The distance cost to water resources is low, with the exception of Cueva Túnel. It should be mentioned, however, that there could have been a local source of water during initial occupations. On the other hand, this site is located a short distance from high-quality rocks, being greater in the case of the other sites – located closer to water. In addition, La Gruta 1 has the highest distance values to lithic resources, which could explain the behavior of tool caching (see Franco et al. 2011, 2018).

According to the available evidence, humans were exploiting the area of the Deseado Massif for more than 2000 years, with almost no evidence of early human presence in nearby places to the south and east. It is probable that during this time, logistical movements to environments located to the east and south had taken place, but there is no support for this idea. Other permanent water sources are present to the south (i.e., Chico River), and they were probably found during regular

**Figure 6** Euclidean distances to water ecological cores and geological formations with high-quality rocks. Distances are in meters.
hunter-gatherer activities. However, high-quality rocks are not that abundant to the south. For example, chalcedonies are present only as small cobbles and are not predictable in their location (Franco et al. 2015).

5. Summary and discussion

Sites which can be attributed to the initial peopling of this area are located at the border of the Deseado Massif. This area continued to be used for more than 2000 years, with people moving back and forth probably using half-radius movements (Binford 1982). There are no other sites with similar chronologies in nearby places. This mobility system is expected given the short stays represented at each place and the general homogeneity of the local environment in terms of shelter, water, rocks, and perhaps fuel.

The general synchrony, the discard rates, and the signs of artifact transport would suggest highly mobile hunter-gatherers, making and carrying bifaces as part of their tool kit. Bifaces and flakes obtained from bifaces were made on high-quality siliceous rocks, sometimes heat-treated (Frank 2012; Miotti and Cattaneo 2003; Vetrison and Franco 2017), which suggest their importance. Due to the short transport distances implied, it is probable that biface utilization was related to its transportability (sensu Nelson 1991) and the lack of knowledge of specific places where high-quality lithic sources could be found within the Deseado Massif itself, thus as a way to solve inconsistencies in resource location (see also Kelly 2003b; Meltzer 2003, 2009). Contrary to what was recorded by Eren and Andrews (2013) for the Lower Great Lakes, in the massif, bifaces were transported and used for tool blanks for knives or side scrapers in some cases (Piedra Museo U6), while in others only last-stage bifacial debitage was recovered, and it is not possible to know which kinds of tools (La Gruta 1) were being manufactured. Distances between sites are not long, but we also cannot assume direct movements between them. In our case, the transport of bifaces seems to have been taking place also sometime after the initial colonization began, when they were deposited in caches. A similar pattern was observed in North America during Clovis times (i.e., Collins 1999; Deller, Ellis, and Keron 2009; Waters and Jennings 2011). Our data suggest local movements, probably within short distances, consistent at least in the southern end of the Massif with the suggested half-radius continuous pattern of movement.

Note

1. Radiocarbon ages were calibrated at the two-sigma probability level in calendar years BP (cal yr BP) using CALIB 7.0 (Stuiver and Reimer 1993) and the Southern Hemisphere (SHcal13) atmospheric calibration curve of Hogg et al. (2013).

Acknowledgements

The original version of this manuscript was presented at the 11th International Symposium on Knappable Materials, held in Buenos Aires, Argentina. Funds were provided by project PICT 2015–2038 (Agencia Nacional de Promoción Científica y Técnica) and PIP 0447 (CONICET). Piedra Grande S.A. and Minera Triton S.A. provided additional help for lodging. We thank three anonymous reviewers, whose comments helped to improve the quality of the paper. Thanks also to Pablo Ramírez (Dirección de Turismo de Gobernador Graores), the owners of La Esmeralda and 17 de Marzo ranches, and to Claudio Iglesias and workers of Piedra Grande S.A. Also we thank all the people who took part of the fieldworks.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by Agencia Nacional de Promoción Científica y Tecnológica: [grant number PICT 2015-2038]; Consejo Consejo Nacional de Investigaciones Científicas y Técnicas [grant number PIP 0447].

Notes on contributors

Nora V. Franco is a Principal Researcher at the CONICET (Consejo Nacional de Investigaciones Científicas y Técnicas) and Professor at the University of Buenos Aires. She obtained her PhD at the University of Buenos Aires and, as part of her formation, she took lithic courses and was part of excavation teams outside of the country. She focuses on lithic studies and is interested in the processes of human peopling of America, human mobility, technology, and strategies of utilization of the space.

Luis A. Borrero obtained a PhD at Universidad de Buenos Aires, Argentina and works as Emeritus Researcher at CONICET and as Emeritus Professor at the University of Buenos Aires, Argentina. His main interests are the process of human colonization of South America, the archaeology of hunter-gatherers, and taphonomy.

Gustavo F. Lucero is a Professor at the University of Cuyo. He graduated in archaeology and his PhD dissertation was in Geography. His main research topic deals with the application of GIS in archaeological analysis, and he has publications on this topic. He also works in rescue archaeology.

References

Anderson, D. G., and J. C. Gillam. 2000. “Paleoindian Colonization of the Americas: Implications from an Examination of Physiography, Demography, and Artifacts Distribution.” American Antiquity 65: 43–66.
Barberena, Ramiro, G. Romero, Gustavo Lucero, M. V. Fernández, Agustina Rughini, and P. Sosa. 2017. “Espacios internoldales en Patagonia septentrional: biogeografía, información y mecanismos sociales de interacción.” Estudios Atacameños. Arqueología y Antropología Surandinas. Epub 13-Mar-2017.

Belardi, Juan Bautista, Pedro Tiberi, Charles Stern, and Alejandro Súñico. 2006. “El Estel del Cerro Pampa: Ampliación del área de Disponibilidad de Obsidiana de la Pampa del Asador (Provincia de Santa Cruz).” Intersecciones en Antropología 7: 27–36.

Bianchi, Cristina, and Rainer Gersonde. 2004. “Climate Evolution at the Last Deglaciation: The Role of the Southern Ocean.” Earth and Planetary Science Letters 228: 407–424.

Binford, Lewis R. 1982. “The Archaeology of Place.” Journal of Anthropological Archaeology 1: 5–31.

Binfold, Lewis R. 2001. Constructing Frames of Reference: An Analytical Method for Archaeological Theory Building Using Ethnographic and Environmental Data Sets. Berkeley: University of California Press.

Bird, Junius. 1969. “A Comparison of South Chilean and Ecuadorean Fishtail Projectile Points.” Kroeber Anthropological Society Papers 40: 52–71.

Bird, Junius. 1988. Travels and Archaeology in South Chile, edited by J. Hyslop. Iowa City: Iowa University Press.

Bird, Douglas W., and James ÓConnell. 2006. “Behavioral Ecology and Archaeology.” Journal of Archaeological Research 14: 143–188.

Blümel, Thomas, J. Schwander, B. Stauffer, T. Stocker, A. Däbben, A. Indmühle, J. Tschumi, J. Chappellaz, D. Raynaud, and J.-M. Barnola. 1997. “Timing of the Antarctic Cold Reversal and the Atmospheric CO2 Increase with Respect to the Younger Dryas Event.” Geophysical Research Letters 24 (21): 2683–2686.

Borrero, Luis A. 1989. “Replanteo de la Arqueología Patagónica.” Interciencia 14 (3): 127–135.

Borrero, Luis A. 1989–1990. “Evolución cultural divergente en la Patagonia Austral.” Anales del Instituto de la Patagonia (Serie Ciencias Sociales) 19: 133–139.

Borrero, Luis A. 1994–1995. “Arqueología de la Patagonia.” Palimpsesto. Revista de Arqueología 4: 9–69.

Borrero, Luis A. 2005. “The Archaeology of the Patagonian Deserts. Hunter-Gatherers in a Cold Desert.” In Desert Peoples: Archaeological Perspectives, edited by Peter Veth, Mike Smith, and Peter Hiscock, 142–158. Oxford: Blackwell Publishing.

Borrero, Luis A. 2011. “The Theory of Evolution, Other Theories, and the Process of Human Colonization of America.” Evolution and Educational Outreach 4: 218–222.

Borrero, Luis A., and Nora V. Franco. 1997. “Early Patagonian Hunter-Gatherers: Subsistence and Technology.” Journal of Anthropological Research 53: 219–239.

Borgomei, Ana María. 2003. “Palynology at Piedra Museo Locality, Santa Cruz Province, Argentina.” In Where the South Winds Blow, edited by Laura Miotti, Mónica Salemme, and Nora Flegenheimer, 113–119. College Station: Center for the Study of First Americans, Texas A&M University.

Brantingham, P. Jeffrey, John W. Olsen, Jason A. Rech, and Andrei I. Krivoshapkin. 2000. “Raw Material Quality and Prepared Core Technologies in Northeast Asia.” Journal of Archaeological Science 27 (3): 255–271.

Brook, G. A., N. V. Franco, P. Ambrústolo, M. V. Mancini, and P. Fernandez. 2015. “Evidence of the Earliest Humans in the Southern Deseado Massif (Patagonia, Argentina), Mylodontidae, and Changes in Water Availability.” Quaternary International 363: 107–125.

Brook, George A., María Virginia Mancini, Nora V. Franco, Florencia Bamonte, and Pablo Ambrústolo. 2013. “An Examination of Possible Relationships between Paleoenvironmental Conditions during the Pleistocene-Holocene Transition and Human Occupation of Southern Patagonia (Argentina) East of the Andes, between 46° and 52°S.” Quaternary International 305: 104–118.

Callahan, Errett. 1979. “The Basics of Biface Knapping in the Eastern Fluted Point Tradition: A Manual for Flintknappers and Lithic Analysts.” Archaeology of Eastern North America 7 (1): 1–180.

Castiñeira, Carola, Judith Charlin, Marcelo Cardillo, and Jorge Baeza. 2012. “Exploring Morphometric Variations in Fishtail Projectile Points From Uruguay, Pampa, and Patagonia.” In Southbound: Late Pleistocene Peopling of Latin America, edited by Laura Miotti, Nora Flegenheimer, Mónica Salemme, and Ted Goebel, 57–61. College Station: Center for the Study of the First Americans.

Cattaneo, Roxana. 2000. “El paisaje y la distribución de recursos líticos en el Nesocratón del Deseado.” In Guía de Campo de la visita a las localidades arqueológicas, Taller Internacional del INQUA International Workshop “La Colonización del Sur de América durante la transición Pleistoceno-Holoceno”, edited by Laura Miotti, Rafael Paunero, Mónica Salemme, and Roxana Cattaneo, 26–35. La Plata: INQUA International Workshop.

Cattaneo, G. Roxana. 2004. “Desarrollo metodológico para el estudio de fuentes de aprovisionamiento lítico en la Meseta Central Santa Cruz, Patagonia Argentina.” Estudios Atacameños 28: 105–119.

Cattaneo, G. Roxana. 2005. “Tecnología lítica en la localidad arqueológica Piedra Museo (Santa Cruz, Argentina).” Relaciones de la Sociedad Argentina de Antropología XXX: 79–103.

Civallerio, Maria Teresa, and Nora V. Franco. 2003. “Early Human Occupations in Western Santa Cruz Province, Southernmost South America.” Quaternary International 109–110: 77–86.

Collins, Michael B. 1999. Clovis Blade Technology. Austin: University of Texas Press.

Conolly, James, and Mark Lake. 2009. Sistemas de Información Geográfica aplicados a la Arqueología. Barcelona: Bellaterra.

Cortesoso, Valeria. 2008. “Disponibilidad de recursos líticos en el noroeste de Mendoza: cambios en la organización tecnológica en la Cuenca del Río Blanco.” Cazadores Recolectores en el Cono Sur 3: 95–113.

Cortesoso, Valeria, Ramiro Barberena, Víctor Durán, and Gustavo Lucero. 2016. “Geographic Vectors of Human Mobility in the Andes (34-36°S): Comparative Analysis of ‘Minor’ Obsidian Sources.” Quaternary International 422: 81–92.

Cueto, Manuel, Ariel D. Frank, and F. Skarбun. 2018. “ExpLOTación de obsidianas in la meseta central de Santa Cruz. Estrategias de producción, uso y circulación.” Chungara. Revista de Antropología Chilena 50 (2): 235–253.
De Giusto, José María, Carlos A. Di Persia, and E. Pezzi. 1980. “Nesocratón del Deseado.” Geología Regional Argentina 2: 1389–1430.

De Porras, María Eugenia. 2010. “Dinámica de la vegetación de la Meseta Central de Santa Cruz durante los últimos 11.000 años: forzantes bióticos y abióticos.” PhD diss., University del Mar del Plata.

Deller, D. Brian, Christopher J. Ellis, and James R. Keron. 2009. “Understanding Cache Variability: A Deliberately Burned Early Paleoindian Tool Assemblage from the Crowfield Site, Southwestern Ontario, Canada.” American Antiquity 74 (2): 371–397.

Dillehay, Tom D., Carlos Ocampo, José Saavedra, Andre Oliveira Sawakuchi, Rodrigo M. Vega, Mario Pino, Michael B. Collins, et al. 2015. “New Archaeological Evidence for an Early Human Presence at Monte Verde, Chile.” PLoS ONE 10 (11): e0141923. doi:10.1371/journal.pone.0141923.

Echeveste, Horacio. 2005. “Travertinos y jasperoides de Manantial Espejo, un ambiente Hot Spring Jurásico. Macizo del Deseado, Provincia de Santa Cruz, Argentina.” Latin American Journal of Sedimentology and Basin Analysis 12 (1): 33–48.

Ellis, Christopher. 2011. “Measuring Paleoindian Range Mobility and Land-use in the Great Lakes/Northeast.” Journal of Anthropological Archaeology 30: 385–401.

Eren, Metin I., and Brian N. Andrews. 2013. “Were Bifaces Used as Mobile Cores by Clovis Foragers in the North American Lower Great Lakes Region? An Archaeological Test of Experimentally Derived Quantitative Predictions.” American Antiquity 78 (1): 166–180.

Eren, Metin I., Christopher I. Roos, Brett A. Story, Noreen von Cramon-Taubadel, and Stephen J. Lyckett. 2014. “The Role of Raw Material Differences in Stone Tool Shape Variation: An Experimental Assessment.” Journal of Archaeological Science 49: 472–487.

Espinosa, Silvana L., and Rafael A. Goñi. 1999. “¡Viven! Una fuente de obsidiana en la Provincia de Santa Cruz.” In Soplando en el viento... Actas de las Terceras Jornadas de Arqueología de la Patagonia, edited by Juan B. Belardi, Pablo Fernández, Rafael Goñi, Ana Gabriela Guraíeb, and Mariana De Nigris, 177–188. Buenos Aires: Instituto Nacional de Antropología y Pensamiento Latinoamericano.

Flegenheimer, Nora, Laura Miotti, and Natalia Mazza. 2013. “Rethinking Early Objects and Landscapes in the Southern Cone: Fishtail-Point Concentrations in the Pampas and Northern Patagonia.” In Paleoamerican Odyssey, edited by Kelly E. Graf, Caroline V. Ketron, and Michael Waters, 359–376. College Station: Center for the Study of the First Americans, Texas A&M University Press.

Flegenheimer, Nora, and Celeste Weitzel. 2017. “Fishtail Points from the Pampas of South America: Their Variability and Life Histories.” Journal of Anthropological Archaeology 45: 142–156.

Flegenheimer, Nora, Celeste Weitzel, and Natalia Mazza. 2015. “Miniature Points in an Exceptional Early South American Context.” World Archaeology 47 (1): 117–136.

Foley, Robert. 1981. “A Model of Regional Archaeological Structure.” Proceedings of the Prehistoric Society 47: 1–17.

Franco, Nora V. 2004. “La organización tecnológica y el uso de escalas espaciales amplias. El caso del sur y oeste de Lago Argentino.” In Temas de Arqueología, Análisis Lítico, edited by Alejandro Acosta, Daniel Lopote, and Mariano Ramos, 101–144. Luján: Universidad Nacional de Luján.

Franco, Nora V. 2012. “Binford and Ethnoarchaeology, a View from the South: Reflections on His Contributions to Hunter-Gatherer Archaeology and Lithic Analysis.” Ethnoarchaeology: Journal of Archaeological, Ethnographic, and Experimental Studies 4 (1): 79–99.

Franco, Nora V., Pablo Ambrústolo, Agustín Acevedo, Natalia Cirigliano, and Miriam Vommaro. 2013. “Prospecciones en el sur del Macizo del Deseado (provincia de Santa Cruz). Los casos de La Gruta y Viuda Quenzana.” In Tendencias teórico-metodológicas y casos de estudio en la Arqueología de la Patagonia, edited by Attilio F. Zangrando, Ramiro Barberena, Adolfo Gil, Gustavo Neme, Miguel Giardina, Leandro Luna, Clara Otaola, Salvador Paulides, Laura Salgán, and Angélica Tívoli, 371–378. Museo de Historia Natural de San Rafael. Buenos Aires: Altuna Impresores.

Franco, Nora V., Pablo Ambrústolo, Marilina Martucci, George A. Brook, María Virginia Mancini, and Natalia Cirigliano. 2010. “Early Human Occupation in the Southern Part of the Deseado Massif (Patagonia, Argentina).” Current Research in the Pleistocene 27: 13–16.

Franco, Nora V., George A. Brook, Natalia A. Cirigliano, Charles Stern, and Lucas Vetrisano. 2017. “17 de Marzo (Santa Cruz, Argentina): A New Distal Source of Pampa del Asador Type Black Obsidian and Its Implications for Understanding Hunter-Gatherer Behavior in Patagonia.” Journal of Archaeological Science Reports 12: 232–243.

Franco, Nora V., Alicia Castro, Natalia Cirigliano, Marilina Martucci, and Agustín Acevedo. 2011. “On Cache Recognition: An Example from the Area of the Chico River (Patagonia, Argentina).” Lithic Technology 36 (1): 37–51.

Franco, Nora V., Natalia Cirigliano, Lucas Vetrisano, and Pablo Ambrústolo. 2015. “Raw Material Circulation at Broad Scales in Southern Patagonia (Argentina): The Cases of the Chico and Santa Cruz River Basins.” Quaternary International 375: 72–83.

Franco, Nora V., Valeria Cortegoso, Gustavo Lucero, and Victor Durán. 2018. “Human Ranking of Spaces and the Role of Caches: Case Studies From Patagonia, Argentina.” Quaternary International 473B: 278–289.

Franco, Nora V., and L. Vetrisano. Forthcoming. “Lithics and Early Human Occupations at the Southern End of the Deseado Massif (Patagonia, Argentina).” In People, Culture in Ice Age Americas: New Directions in Paleoamerican Archaeology, edited by R. Suárez and C. F. Ardelean, 13–33. Salt Lake City: University of Utah Press.

Frank, Ariel. 2012. “Heat Treatment of Lithic Artifacts in Early Sites from the Central Plateau of Santa Cruz (Argentina).” In Southbound: Late Pleistocene Peopling of Latin America, edited by Laura Miotti, Mónica Salemme, Nora Flegenheimer, and Ted Goebel, 155–158. College Station: Center for the Study of the First Americans, Texas A&M University.

Glasser, N. F., S. Harrison, C. Schnabel, D. Fabel, and K. N. Janss. 2012. “Younger Dryas and Early Holocene Age Glacier Advances in Patagonia.” Quaternary Science Reviews 58: 7–17.

Goodyear, Albert C. 1989. “A Hypothesis for the Use of Cryptocrystalline Raw Materials among Paleo-Indian Groups of North America.” In Eastern Paleoindian
Miotti, Laura. 1992. “Paleoindian Occupation at Piedra Museo Locality, Patagonian Region, Argentina.” *Current Research in the Pleistocene* 9: 30–32.

Miotti, Laura, Darío Hermo, and Enrique Terranova. 2010. “Fishtail Points, First Evidence of Late-Pleistocene Hunter-Gatherers in Somuncurá Plateau (Río Negro Province, Argentina).” *Current Research in the Pleistocene* 27: 22–24.

Miotti, Laura, and Lucía Magnin. 2012. “South America 18,000 Years Ago: Topographic Accessibility and Human Spread.” In *Southbound: Late Pleistocene Peopling of Latin America*, edited by Laura Miotti, Mónica Salemme, Nora Flegenheimer, and Ted Goebel, 19–23. College Station: Center for the Study of the First Americans, Texas A&M University.

Miotti, Laura, and Gabriela Roxana Cattaneo. 2003. “Variation in the Strategies of Lithic Production and Faunal Exploitation during the Pleistocene/Holocene Transition at Piedra Museo and Surrounding Region.” In *Where the South Winds Blow: Ancient Evidences of Paleo South Americans*, edited by Robert Bonnichsen, Laura Miotti, Mónica Salemme, and Nora Flegenheimer, 105–111. College Station: Center for the Studies of the First Americans, Texas A&M University.

Miotti, Laura, and Mónica Salemme. 2004. “Peopling, Mobility and Territories between the Hunter-gatherer Populations in Patagonia.” *Complutum* 15: 177–206.

Miotti, Laura, Mónica Salemme, and Jorge Rabassa. 2003. “Radiocarbon Chronology at Piedra Museo Locality.” In *Where the South Winds Blow, Ancient Evidences of Paleo South Americans*, edited by Laura Miotti, Mónica Salemme, and Nora Flegenheimer, 99–104. College Station: Center for the Study of First Americans, Texas A&M University Press.

Moreno, Patricio I., Rodrigo Villa-Martínez, Macarena L. Cárdenas, and Esteban A. Sagredo. 2012. “Deglacial Changes of the Southern Margin of the Southern Westerly Winds Revealed by Terrestrial Records from SW Patagonia (52°S).” *Quaternary Science Reviews* 41: 1–21.

Nami, Hugo G. 1986. “Experimentos para el estudio de la tecnología bifacial de las ocupaciones tardías en el extremo sur de la Patagonia Continental.” *PREP: Informes de Investigación* 5, 7–120. Buenos Aires.

Nami, Hugo G. 1987. “Cueva del Medio: perspectivas arqueológicas para la Patagonia Austral.” *Anales del Instituto de la Patagonia (Serie Ciencias Sociales)* 17: 73–106.

Nami, Hugo G. 2003. “Experimentos para explorar la secuencia de reducción Fell de la Patagonia Austral.” *Magallania* 31: 107–138.

Nami, Hugo. 2014. “Observaciones para conocer secuencias de reducción bifaciales paleoindias y puntas Fell en el valle del Illaló, Ecuador.” In *Población de América del Sur: la contribución de la tecnología lítica. Proceedings of the XVI World Congress of the International Union of Prehistoric and Protohistoric Sciences*. Archéoéditions.

Nami, Hugo, Martín Giecco, Alicia Castro, and Michael Glascoc. 2018. “New Analysis of Late Holocene Obsidians from Southern Patagonia (Santa Cruz Province, Argentina).” *Bulletin of the International Association for Obsidian Studies* 57: 13–23.

Nelson, Margaret C. 1991. “The Study of Technological Organization.” In *Archaeological Method and Theory, Edited by Michael Schiffer*, Volume 3, 57–100. Tucson: University of Arizona Press.

Panza, José L., and Miguel J. Haller. 2002. “El volcanismo Jurásico.” In *Geología y Recursos Naturales de Santa Cruz. Relatorio del XV Congreso Geológico Argentino*, edited by Miguel Haller, 89–101. Actas I. Buenos Aires: Asociación Geológica Argentina.

Panza, José L., and Graciela Marin. 1998. “Geología.” In *Hoja Geológica 4969-1 “Gobernador Gregores”, Provincia de Santa Cruz*. Boletín 239, 1–104. Buenos Aires: SEGEMAR.

Paruelo, José M., Adriana B. Beltrán, Esteban Jobbágy, Osvaldo E. Sala, and Rodolfo A. Golluscio. 1998. “The Climate of Patagonia: General Patterns and Controls on Biotic Process.” *Ecología Austral* 8: 85–101.

Paunero, Rafael S. 2000. “Localidad arqueológica Cerro Tres Tetas.” In *Guía de Campo de la visita a las localidades arqueológicas*, edited by Laura Miotti, Rafael Paunero, Mónica Salemme, and Roxana Cattáneo, 89–100. INQUA International Workshop “La Colonización del Sur de América durante la transición Pleistoceno/Holoceno”. INQUA International Workshop: La Plata.

Paunero, Rafael S. 2003a. “The Cerro Tres Tetas (C3T) Locality in the Central Plateau of Santa Cruz, Argentina.” In *Where the South Winds Blow: Ancient Evidences of Paleo South Americans*, edited by R. Bonnichsen, L. Miotti, M. Salemme and, and N. Flegenheimer, 133–140. College Station: Center for the Studies of the First Americans, Texas A&M University.

Paunero, Rafael S. 2003b. “The Presence of a Pleistocene Colonizing Culture in La María Archaeological Locality, Casa del Minero 1.” In *Where the South Winds Blow: Ancient Evidences of Paleo South Americans*, edited by R. Bonnichsen, L. Miotti, M. Salemme and, and N. Flegenheimer, 127–132. College Station: Center for the Studies of the First Americans, Texas A&M University.

Paunero, Rafael. 2009. “La colonización humana de la meseta central de Santa Cruz durante el Pleistoceno final: indicadores arqueológicos, referentes estratigráficos y nuevas evidencias.” In *Arqueología de Patagonia: una Mirada desde el Último Confin*, edited by Mónica C. Salemme, Fernando Santiago, Myrian Álvarez, Ernesto Piana, Martín Vázquez, and María Estela Mansur, 85–100. Ushuaia: Editorial Utopias.

Paunero, Rafael S., Ariel D. Frank, Manuel Cueto, Fabiana Skarbn, and Catalina Valiza Davis. 2015. “La ocupación pleistocénica de cueva Túnel, meseta central de Santa Cruz: un espacio que reúne actividades en torno al procesamiento primario de presas.” *Aték Na* 5: 149–188.

Paunero, Rafael S., Ariel D. Frank, Fabiana Skarbn, G. Rosales, Manuel E. Cueto, G. Zapata, Matías F. Paunero, N. Lunazzi, and Martín Del Giorgio. 2007. “Investigaciones arqueológicas en sitio Casa del Minero 1, Estancia La María, Meseta Central de Santa Cruz.” In *Arqueología de Fuego-Patagonia. Levantando Piedras, Desenterrando Huéspes… y Develando Arcanos*, edited by Flavia Morello, Alfredo Prieto, Mateo Martinic, and Gabriel Bahamonde, 577–588. Punta Arenas: Centro de Estudios del Cuaternario Antártico.

Pérez, S. Iván, María Bárbara Postillone, Diego Rindel, Diego Gobbo, Paula N. González, and Valeria Bernal. 2016. “Peopling Time, Spatial Occupation and Demography of Late Pleistocene-Holocene Human Population from Patagonia.” *Quaternary International* 425: 214–223.
Politis, Gustavo G., Pablo G. Messineo, and Cristian A. Kaufmann. 2004. “El poblamiento temprano de las llanuras pampenanas de Argentina y Paraguay.” Complutum 15: 207–224.

Ponce, Juan Federico, Ana María Borromei, and Jorge Oscar Rabassa. 2011. “Evolución del paisaje y de la vegetación durante el Cenozoico tardío en el extremo suroeste del archipiélago Fueguino y Canal Beagle. Los cazadores-recolectores del extremo oriental fueguino.” In Arqueología de península Mitre e Isla de los Estados, edited by A. F. Zangrandi, M. Vázquez, and A. Tessone, 31–64. Buenos Aires: Sociedad Argentina de Antropología.

Rademaker, Kurt, David Reid, and Gordon M. Bromley. 2012. “Connecting the Dots.” In Least Cost Analysis of Social Landscapes: Archaeological Case Studies, edited by Devon White and Sara Surface-Evans, 32–45. Salt Lake City: University of Utah Press.

Roig, Fidel A. 1998. “La vegetación de la Patagonia.” In Flora Patagónica, edited by M. N. Correa, Colección Científica INTA 8 (1): 47–166.

Salame, Mónica C., and Laura L. Miotti. 2008. “Arqueológico Hunter-gatherer Landscapes since the Latest Pleistocene in Patagonia.” In The Late Cenozoic of Patagonia and Tierra del Fuego, edited by Jorge Rabassa, 437–483. Developments in Quaternary Science 11, edited by J. der Meer. Amsterdam: Elsevier.

Skarbun, Fabiana. 2009. “La organización tecnológica en grupos cazadores-recolectores desde las ocupaciones del Pleistoceno final al Holoceno Tardio en la Meseta Central de Santa Cruz.” PhD diss., Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, La Plata, Argentina.

Skarbun, Fabiana. 2012. “Variability in Lithic Technological Strategies of Early Human Occupations from the Central Plateau, Santa Cruz, Argentina.” In Southbound: Late Pleistocene Peopling of Latin America, edited by Laura Miotti, Mónica Salamé, Nora Flegenheimer, and Ted Goebel, 143–147. College Station: Center for the Study of the First Americans, Texas A&M University.

Skarbun, Fabiana, Ariel Frank, Manuel Cueto, and Rafael Paunero. 2015. “Producción, consumo y espacialidad en Cueva Túnel, Meseta Central de Santa Cruz, Argentina.” Chungara. Revista de Antropología Chilena 47 (1): 85–99.

Skarbun, Fabiana, Ariel Frank, Matías Paunero, Manuel Cueto, and Gabriela Rossales. 2007. “Análisis de la tecnología lítica del sitio Casa del Minero 1, Meseta Central de Santa Cruz.” In Arqueología de Fuego-Patagonia. Levantando Piedras, Desenterrando Huesos... y Desvelando Arcanos, edited by Flavia Morello, Alfredo Prieto, Mateo Martinic, and C. Bahamonde, 589–600. Punta Arenas: CEIDER.

Smith, Geoffrey M. 2015. “Modeling the Influences of Raw Material Availability and Functional Efficiency on Obsidian Projectile Point Curation: A Great Basin Example.” Journal of Archaeological Science: Reports 3: 112–121.

Soriano, Alberto. 1983. “Deserts and Semideserts of Patagonia.” In Temperate Deserts and Semi-deserts, edited by Neil E. West, 423–460. Amsterdam: Elsevier.

Steele, James, and Gustavo Politis. 2009. “AMS 14C Dating of Early Human Occupation of Southern South America.” Journal of Archaeological Science 36: 419–429.

Stern, Charles R. 2000. “Sources of Obsidian Artifacts from the Pali Aike, Fell's Cave and Canadón La Leona Archaeological Sites in Southernmost Patagonia.” In Desde el País de los Gigantes. Perspectivas arqueológicas en Patagonia, 43–55. Río Gallegos: Ed. Universidad Nacional de la Patagonia Austral.

Suivier, Minze, and Paula J. Reimer. 1993. “Extended 14C Database and Revised CALIB Radiocarbon Calibration Program.” Radiocarbon 35: 215–230.

Suatez, Rafael. 2010. “Arqueología durante la transición Pleistoceno-Holoceno: componentes Paleoindios, organización de la tecnología lítica y movilidad de los primeros americanos en Uruguay.” PhD diss., Facultad de Ciencias Naturales y Museo, Universidad de La Plata, La Plata, Argentina.

Tachikawa, Tetsushi, Masami Hato, Manabu Kaku, and Akira Iwasaki. 2011. “Characteristics of ASTER GDEM Version 2.” In International Geoscience and Remote Sensing Symposium (IGARSS), 3657–3660. doi:10.4067/S0718-1043201700500006.

Tomaso, Antonin, and Guillaume Pourraz. 2016. “Hunter-gatherer Mobility and Embedded Raw-material Procurement Strategies in the Mediterranean Upper Paleolithic.” Evolutionary Anthropology 25 (3): 164–174.

Tripecevich, Nicholás. 2008. “Llama Caravan Transport: A Study of Mobility with a Contemporary Andean Salt Caravan.” In Book of Abstracts of the 73rd Annual Meeting of the Society for American Archaeology, Vancouver. Washington, DC: Society for American Archaeology.

Veth, Peter. 2005. “Cycles of Aridity and Human Mobility: Risk Minimization among Late Pleistocene Foragers of the Western Desert, Australia.” In Desert Peoples: Archaeological Perspectives, edited by P. Veth, M. Smith, and P. Hiscock, 100–115. Oxford: Blackwell Publishing.

Vetrisano, Lucas, and Nora V. Franco. 2017. “Heat Treatment and Changes in Siliceous Rock Quality in the Southern End of the Deseado Massif (Patagonia, Argentina).” In 11th International Symposium on Knappable Materials, “From Toolstone to Stone Tools”, Book of Abstracts, edited by Jimena Alberdi, Karen Borrazzo, Silvana Buscaglia, Alicia Castro, Alejandra Elias, and Nora V. Franco, 28. Buenos Aires: IMHICIHU-CONICET.

Vetrisano, Lucas, and Nora V. Franco. Forthcoming. “El registro arqueológico de espacios al aire libre y bajo roca en el extremo meridional del Macizo del Deseado: la integración de información de superficie y estratégica.” Décimas Jornadas de Arqueología de la Patagonia. Puerto Madryn: IDEAUS-CONICET.

Waters, Michael, and Thomas A. Jennings. 2011. The Hogeye Clovis Cache. College Station: Texas A&M University Press.

Wheatley, David, and Mark Gillings. 2002. Spatial Technology and Archaeology. The Archaeological Applications of GIS. London: Taylor & Francis.

Zubia, Mario. 1998. “Recursos Minerales.” In Hoja Geológica 4969-1 “Gobernador Gregores”, Provincia de Santa Cruz. Boletín 239, 75–80. Buenos Aires: SEGEMAR.