Journal of Archaeological Science: Reports 7 (2016) 420–431

Contents lists available at ScienceDirect

Journal of Archaeological Science: Reports

journal homepage: www.elsevier.com/locate/jasrep

Miraflores rocks in Tierra del Fuego (southernmost South America): Hunter-gatherer procurement, optimal pathway analysis and social interaction

María Cecilia Pallo *, Karen Borrazzo

IMHICIHU, CONICET and Universidad de Buenos Aires, Saavedra 15, 5th floor, 1083 ACA Buenos Aires, Argentina

ARTICLE INFO

Article history:
Received 20 December 2015
Received in revised form 10 May 2016
Accepted 11 May 2016
Available online xxxx

Keywords:
Lithic raw material
GIS
Spatial distribution
Social interaction
Hunter-gatherer mobility
Tierra Del Fuego

ABSTRACT

Using GIS applications to simulate optimal human movements from archaeological sites to the lithic source known as Miraflores Valley (Isla Grande de Tierra del Fuego, Southernmost South America), this paper discusses potential pathways for the spatial distribution of artifacts made of the two distinctive Miraflores raw materials (tuff and silicified tuff). In addition, we discuss possible models of exploitation and transport for Miraflores rocks through a distributional analysis on the depositional environment of the findings. Archaeological collections as well as petrographic and geochemical studies show a large-scale archaeological distribution of Miraflores rocks; however they are absent from most Fuegian lithic assemblages and scarce in those wherein they appear. We propose and discuss the provisioning strategies applied in their procurement. Potential pathways through the islandscape are correlated with a statistical analysis based on the location of sites with the presence or absence of Miraflores raw materials. Spatial analyses provide a robust framework to discuss Miraflores distribution and circulation, human mobility as well as the social interaction among terrestrial hunter-gatherers and maritime populations of southernmost South America. Our results indicate that Miraflores rocks procurement varied across Fuegian geography. While independent circuits and multiple accesses to the source may have existed in the north of Isla Grande de Tierra del Fuego, the distribution of these rocks southwards may have had a higher dependence on a few optimal routes connected to northern archaeological localities of San Sebastián and Inútil Bays. Therefore, southern populations may have drawn heavily on social interaction for the supply of Miraflores raw materials. Nevertheless, Least Cost Path model suggests that the participation of canoe people was not required to explain the current distribution of Miraflores materials throughout the Isla Grande de Tierra del Fuego.

1. Introduction

Studies of lithic raw material distribution are an essential part of archaeological approaches to the use of space, human mobility, and networks of social interaction (i.e. Renfrew, 1977; Meltzer, 1989; Feblot-Augustins, 1993; Haury, 1995; Beck et al., 2002; Brantingham, 2003, 2006). However, the identification of patterns is usually limited by the requirement for a known source of each raw material. More frequently, most of the latter were obtained from secondary geological deposits, which are one of the most ubiquitous features within archaeological landscapes (Torrence, 1989; Andrefsky, 1994; Franco, 2002, 2014; Charlin, 2009).

In the Isla Grande of Tierra del Fuego (52–54° S, 66–74° W, southernmost South America) the only primary source with evidence of use identified so far is located in the Chorrillo Miraflores Valley, on the northern steppe (Prieto et al., 2004) (Fig. 1). Recent archaeological research showed that two raw materials (tuff and silicified tuff) available at that source were transported up to 320 km away and also off shore. These rocks were recorded in archeological contexts of several small islands in the Strait of Magellan and on the coasts of continental Patagonia, suggesting some level of interaction between terrestrial and maritime hunter-gatherers (Prieto et al., 2004; Borrazzo et al., 2008, 2010, 2015; Borrazzo, 2009, 2012; Massone, 2009; De Ángelis, 2012; Morello et al., 2012; Labarca et al., 2014; Borrazzo and Pallo, 2015). The earliest chronology available for the human use of these lithologies is *c.* 4000–3000 YBP (Morello et al., 2012; Borrazzo et al., 2015). Regional studies indicated that Miraflores tuff has been used as wood shaft polishers and/or as grinding stones, while the silicified tuff was primary reduced through the application of the bipolar technique and used in the manufacture of (micro) end-scrapers (Prieto et al., 2004; Borrazzo et al., 2015).

A large scale survey of Fuegian lithic collections was recently undertaken to assess overall contribution of Miraflores raw materials to

* Corresponding author.
E-mail addresses: ceciliapallo@gmail.com (M.C. Pallo), kborrazzo@yahoo.com.ar (K. Borrazzo).

http://dx.doi.org/10.1016/j.jasrep.2016.05.024
2352-409X/

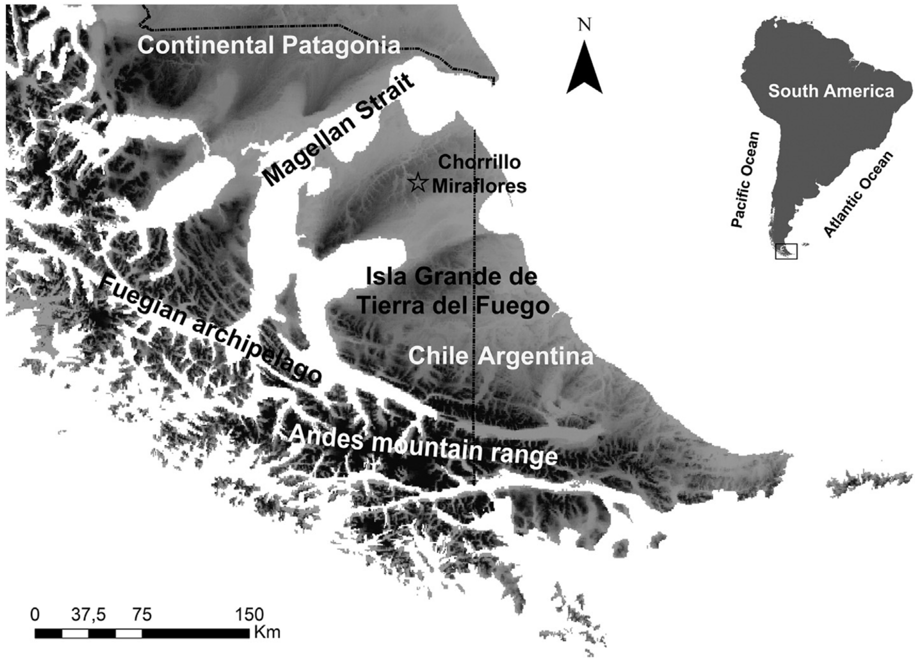

Fig. 1. Isla Grande de Tierra del Fuego and the location of Chorrillo Miraflores source.

lithic assemblages from Isla Grande de Tierra el Fuego. The results indicate that both rocks are absent from most of known archaeological sites and their frequencies in the assemblages is, in general, extremely low (Borrazzo et al., 2015). This trend suggests these raw materials were not systematically or intensively transported and/or traded; on the contrary, the archaeological occurrence of Miraflores artifacts fits better with an incidental desposition. Nevertheless, with the exception of Miraflores raw materials, there has not been an identifiable Fuegian lithic raw material with an appropriate distribution for assessing mobility patterns within the island. Thus discussion has mainly focused on the archaeological distribution of marine resources and their isotopic signal in the bioarchaeological record. This resulted in a focus on the study of coast-interior mobility, and less attention has been paid to the possible interaction between the northern and southern parts of the island. Therefore, Miraflores as localized Fuegian lithic raw materials, offer the possibility of addressing other spatial vectors of human circulation and group interaction within the island. Finally, the remarkable status of Miraflores raw materials for the archaeology of southern tip of South America is emphasized by the recovery of their artifacts from sites located far south of the island, on small neighbor islands, and the coast of continental Patagonia (Borrazzo et al., 2015).

In this paper we address three main topics of the distribution of Miraflores rocks. First we asses if the differences recorded in the manufacture and use of tuff and silicified tuff (Borrazzo, 2012) expresses in their spatial distribution. Second, we explore possible pathways in the circulation of Miraflores raw materials to contribute to the discussion on provisioning strategies. Finally, we evaluate the involvement of canoe people in Miraflores distribution in the southernmost region of South America.

Drawing on abundant data available from multiple lines of evidence (archaeological, petrographic, and geochemical studies) and current environmental information at a large scale, GIS approaches offer a powerful tool to develop our research (i.e. Kvamme, 1999; Conolly and Lake, 2006; Howey, 2007; Taliaferro et al., 2010; Clarkson and Bellas, 2014). With this tool, we generated a model of optimal circulation of Miraflores rocks through the islandscape, which then correlated with a statistical analysis based on site location.

2. Background

Isla Grande de Tierra del Fuego (currently divided between Chile and Argentina) is the largest island of the Fuegian Archipelago; the western smaller islands constitute a complex network of channels (Fig. 1). Tierra del Fuego was one of the last regions in occupied by terrestrial hunter-gatherers at some time during the Pleistocene-Holocene Transition (11,000 to 9000 BP, Morello et al., 2012) and prior to the definite flooding of the Strait of Magellan (ca. 8000 BP, Clapperton, 1992; McCulloch et al., 1997). The dominant environmental trend in the region is oceanic, with strong *southern westerlies* (Coronato, 1993). Present vegetation patterns are the result of a NW-SE gradient in precipitation and temperature (Luebert and Pliscoff, 2006; Allué et al., 2010; Coronato, 2014). Peat and evergreen forest occupy the Andes Range on the Pacific Islands and southern Isla Grande; deciduous forest growing up in the south of Isla Grande rises towards the central hills of the region, while the Patagonian steppe with grasslands and shrubs extends to the lower hills and plains of the north (Moore, 1983) (Fig. 2).

Archaeological and ethnohistorical information from the Fuegian Archipelago suggests that social interaction among terrestrial and maritime populations was probably taking place at least since 4000–3000 BP (Labarca et al., 2014; Legoupil et al., 2011; Morello et al., 2012), which also included overlapping land use on the west coast of the Isla Grande (Gusinde, [1937] 1982; Ocampo and Rivas, 1996; Yesner et al., 2003). At least four human groups were involved in this processes during historic times: the Selk'nam (terrestrial hunter-gatherers of northern and central Isla Grande), the Káweskar (maritime hunter-gatherers from the western islands), the Yamana (maritime hunter-gatherers of the Beagle Channel, southern coast of Isla Grande and the southern islands of the Fuegian Archipelago), and the Haush (a small group inhabiting south-eastern sector of Isla Grande) (Yesner et al., 2003; Zangrando et al., 2012).

Since the Early Holocene, lithic raw materials employed by hunter-gatherers of northern Isla Grande were mainly obtained from secondary deposits of glacial, fluvial, and/or marine origin widely available in the region. The Chorrillo Miraflores Valley (Fig. 1) is so far the only primary lithic source in Tierra del Fuego. The two lithologies available at the source (tuff and silicified tuff) exhibit unique macroscopic, petrographic, and geochemical features that proved to be reliable in differentiating them from other rocks (silicified rocks, chert, chalcedony, rhyolite,

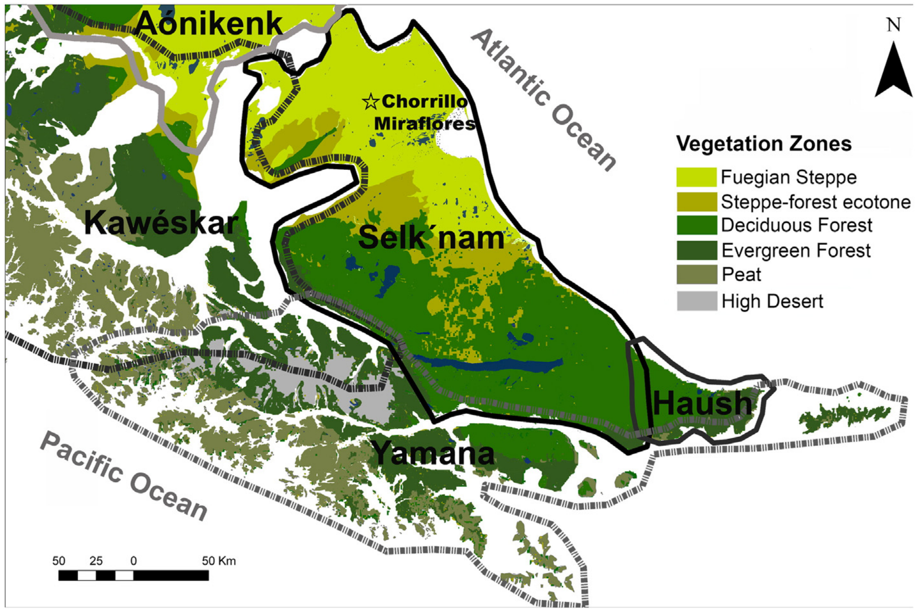

Fig. 2. Primary vegetation zones (modified from Luebert and Pliscoff, 2006; Allué et al., 2010) and distribution of the main ethnic groups known for southernmost South America by the time of European Contact (after Lothrop, 1928). Foot Indians: Aónikenk, Selk'nam, and Haush. Canoe Indians: Yamana and Kawéskar (after Gusinde, [1937] 1982; Martinic, 1995).

basalt, among others) available in the region (Borrazzo et al., 2010, 2015). Outcrops appear primary on the northern hills of the Miraflores Valley and several small surface sites that remain to be surveyed were recorded on the flood plain, near the spring (Prieto et al., 2004; Borrazzo, 2012; Borrazzo et al., 2015).

Miraflores tuff is a bright, reddish color rock with eutaxitic texture. It was worked by grinding and used for wood shaft polishers and/or as grinding stones. Silicified tuff is an isotropic rock of variable knapping quality (very good to poor, depending on the frequency of impurities and/or degree of silicification). It displays a variable range of colors (light bluish-gray to black, with red specks), but its unique and diagnostic feature is a glassy luster lacking in other lithic raw materials of Isla Grande. In addition, the absence of silicified tuff in other potential lithic sources surveyed throughout the island strongly supports Chorrillo Miraflores as the natural source for all of the silicified tuff artifacts. For the tuff, a small secondary Mid-Holocene source is also available at 25 km SE of Miraflores Valley, where small (~10 cm) rounded pebbles of this rock are included in the margins of a temporary lake. Analyses showed these nodules exhibit the same geochemical trend recorded at Chorrillo Miraflores source. It was proposed that nodule shape (rounded) would be a sensitive element to distinguish both sources (Borrazzo et al., 2010; Borrazzo, 2012; Borrazzo et al., 2015), although no evidences of the use of this source were recorded. Nevertheless, considering its location (25 km away from Miraflores), small extension (~100 m, Borrazzo et al., 2010, 2015), secondary character and the size and shape of its nodules, we consider these deposits as a minor (sub) source or the spur of Chorrillos Miraflores source at the large scale of our study.

Silicified tuff was widely transported, processed, and used in spaces where other lithic resources of overall better knapping quality (consistently fine-grained, homogeneous, lacking inclusions and cleavage, etc.; Aragón and Franco, 1997) were locally available. Only small pieces of silicified tuff are homogeneous and exhibit very good to excellent flaking quality (*sensu* Aragón and Franco, 1997). Since knappers may have selected the best quality flakes as blanks for tool manufacture, only small-sized pieces underwent further reduction by the application of the bipolar technique and were used for tool manufacture as well. This behavior was proposed as a technological response intended to allow the exploitation of this raw material (Borrazzo, 2012). Since good quality tool stone is available at or near every archaeological site where silicified tuff was recorded, it can be reasonably assume that hunter-gatherers did not need raw material supplies to meet immediate demand. However, the higher functional efficiency and/or durability of it edges over other local good quality raw materials (De Ángelis, 2012) may account for at least part of its selection and long-distance transport. Nevertheless, its absence or low frequency within Fuegian archaeological assemblages suggests other factors conditioned its distribution.

The most common stone tool manufactured from Miraflores silicified tuff are end-scrapers, one of the most curated and morphologically standardized tool-types of Tierra del Fuego. Use-wear analysis showed that Fuegian end-scrapers exhibit a high degree of functional integrity (Álvarez, 2004; De Ángelis, 2012). Indeed, the southernmost occurrence of silicified tuff in an archaeological assemblage is represented by an endscraper and small flake at Bahía Valentín site 11 (Vidal, 1988; Zangrando et al., 2012), on the southeastern coast of Tierra del Fuego. There are no evidences of projectile point manufacture on silicified tuff despite the presence of a ~7 cm biface recorded at Inútil Bay area (Prieto et al., 2004).

3. Materials and methods

3.1. Materials

The data for the present work derive primarily from an extensive survey of Fuegian lithic artifact collections stored in Chilean and Argentinean institutions. Over two hundred Fuegian archaeological assemblages were surveyed (N = 95.124 artifacts), all of which are considered for the present work. However, only a minor portion of them includes one or both Miraflores rocks (n = 48 assemblages) and their frequency is extremely low, representing <0.2% (N = 178, silicified tuff) and 0.07% (N = 65, tuff) of the total sample examined (Borrazzo et al., 2015). Most of the assemblages including Miraflores rocks are surface collections.

For the present study we also consider the archaeological data on this raw materials published by other researcher (De Ángelis, 2012; Morello et al., 2012; Labarca et al., 2014; Langlais, 2016). Current chronological data of stratigraphic contexts as well as geological time frame available for several surface collections indicate that the earliest use for Miraflores raw materials was *c.* 4000–3000 YBP.

3.2. Methods

3.2.1. Optimal pathway analysis

Hypothetical pathways connecting the surveyed sites and the Miraflores source were estimated from a Least cost path (LCP) analysis using the ArcGis 9.3 Spatial Analyst extension. By using this methodology, the most optimal route between two points is modelled, taking into account the distance and the cost of traveling over irregular terrains (see ESRI Release ArcGIS 9.3.1 for a summary of the LCP function). The cost surface was based on isotropic models which consider the same cost of travelling through space in all directions (Tobler, 1993). In this case, the aspect (orientation) was not considered since altitudinal levels across the distribution area of Miraflores rocks do not show significant changes. In terms of refining the methodology, it seems that the model could not be significantly improved by incorporating the anisotropy into the cost of surface.

Using a multi-criteria model, that provides significant advantages over simple models based on unique regional environmental factors (Howey, 2007), aspects of physical geography -slope, vegetation, and hydrography- were considered taking into account the main requirements of pedestrian mobility among ethnographic hunter-gatherers (Binford, 2001) and, in particular, Fuegian people of historic times (Bridges [1878] 1998; Serrano Montaner, [1879] 2002; Popper, [1887 1893] 2003; Gallardo [1910] 1998; Gusinde, [1937] 1982).

In this sense, LCP analysis was carried out in agreement with basic principles of optimality models in Human Behavioral Ecology (Krebs and Davies, 1987; Bird and O'Connell, 2006; Nettle et al., 2013). The primary assumption was that hunter-gatherers expended a large proportion of their energy and time on their feet, traveling to acquire and transport resources. Thus mobility appears closely linked to strategies of energy use and resource acquisition (Krebs and Davies, 1987). Higher latitude hunter-gatherers tend to exhibit higher mobility and to practice techniques to reduce mobility costs (Binford, 2001). Due to the fact that hills are energetically more costly to travel over than plain landscapes, we assume terrestrial hunter-gatherers would avoid steep slopes. Moreover, considering they pursue energy saving and security in long-distance travels, they would also avoid moving along environments with very humid and closed wooded vegetation as well as lands with snow-capped peaks (Martinic, 1995; Bridges, [1878] 1998; Serrano Montaner, [1879] 2002: 183; Pooper, [1887] 2003: 59). Therefore, moving through low slope, open and steppe environments, with available nearby water sources, such as rivers and lakes margins, should have been less costly for Fuegian hunter-gatherers (Serrano Montaner, [1879] 2002:197–198; Popper, [1887 and 1893] 2003:70). Nevertheless, it is worth mentioning that other mechanisms may produce the incidental deposition of exotic goods (e.g. visits; Borrero et al., 2011; Pallo and Borrero, 2015).

Given these behavioral principles, the cost surface was calculated by combining the slope of a 30 m digital elevation model from the *ASTER Global Digital Elevation Model* (ASTER DEM), and the vegetation and the hydrography from digitized information for Argentina (IGN, 2013–2015) and Chile (Luebert and Pliscoff, 2006). Since water is a critical resource for humans, buffer areas along river, lakes, and lagoon margins were also included as priority areas in the model. In contrast, lakes and lagoons have a high value in order to avoid "puddle jumping" (see Howey, 2007), but due to their low volumes and insignificant dimensions, it is likely that most water bodies posed a minimal impediment to travel (Gallardo, [1910] 1998; Gusinde, [1937] 1982; Pallo, 2012a). All this information was reclassified and combined into a total accumulated cost distance surface, which shows a higher degree of difficulty for circulation as the slope, the thickness of the vegetation cover, and the lack of surface water increase (Fig. 3). Table 1 shows the value of each element of the landscape. Assigning cost values of each variable follows a previous approach to the effort of human movement through the Fuegian islandscape (Pallo, 2012b). In this regard, the method assumes certain operational arbitrariness on the quantification of variables, since there are other technical tools and parameters that can give different results to our classification. Thus, according to the elements available, a value (cost) is assigned to each area. For example, a landscape with a surface exhibiting a 0–10° slope, a permanent lake and steppe land vegetation have a total accumulated cost of 102. On this multi-criteria cost distance surface, least cost paths were calculated employing the most common tree-building algorithms used in GIS, originally developed by Dijkstra (1959).

There are clearly limitations in LCP model, mainly due to the lack of information on the magnitude of climate fluctuations (i.e. temperature, precipitation, humidity, and intensity of winds) during the Late Holocene (Pallo and Ozán, 2014). Potential regional effects of paleoenvironmental events on past Fuegian populations, such as the Medieval Climatic Anomaly (Stine, 1994; Mauquoy et al., 2004), the Little Ice Age (Luckman and Villalba, 2001; Chambers et al., 2014), the tree line fluctuations (Heusser, 1993) and the Atlantic shoreline changes (Codignotto and Malumian, 1981, Vilas et al., 1999; Bujalesky, 2007), are still poorly understood. Neither the wind or the winter snows, that would be great potential factors to modify the cost of movement across the region (Bridges [1878] 1998; Popper [1887 and 1893] 2003; Gallardo [1910] 1998), nor the historical territorial boundaries, that could have affected the mobility patterns and the social islandscape in the past, were considered (Chapman, 1986).

Notwithstanding these issues, the general paleoclimatic model for Tierra del Fuego emphasizes environmental stability of past 3000 years, including the relative constancy over the variables that make up the LCP model (Rabassa et al., 2000; Moy et al., 2009; Borromei et al., 2010; Coronato, 2014). Accordingly, the model focuses on the use of present-day environmental differences to rank landscape features which deals with optimal human movement on a qualitative scale. Measured trends in the LCP model are interpreted in a long-term scale, reflecting redundancy or persistent use of certain spaces for human movement during the Late Holocene.

3.2.2. Distributional analysis

At the regional scale, Fuegian archaeological assemblages considered for the present work ($N = 280$) are located in different types of landforms and Fuegian environments, in areas up to 320 km away from the source (Borrazzo et al., 2015). We characterized the spatial distribution of all sites with the tuff (RT) and the silicified variety (ST) and without Miraflores raw materials, to discuss possible models of exploitation and transport for both raw materials, according to their depositional context (Table 2).

In order to achieve this goal, we compared site frequencies per landform and environment by means of Chi^2 test for contingency tables (Hammer et al., 2001). Landforms include marine, fluvial, lacustrine and outcrops/tertiary deposits (Frederiksen, 1988), while environments were classified into coastal and interior areas. Since some counts are less than five cases, *p*-value was calculated using Monte Carlo simulation approach (Cardillo and Alberti, 2013). In addition standardized residuals (of the difference between observed and expected frequency for each cell) were examined in order to determine in which cell (s) the null hypothesis of independence is rejected at a significance level of $\alpha = 0.05$.

4. Results

4.1. Least cost path (LCP) analysis

The results of the LCP model indicate that there are two main entries to Miraflores source, north and south through the valley (Fig. 4). Headwaters of the valley are the optimal and more direct way of reaching the source from sites located in northern coastal environments. In contrast, the mouth of the valley holds a broader spatial connection with sites located on the northwestern coast and those in the centre and south of the Island Grande. As an exception, the model finds a third optimal access to the source from the west border of Chorrillo Miraflores. This western

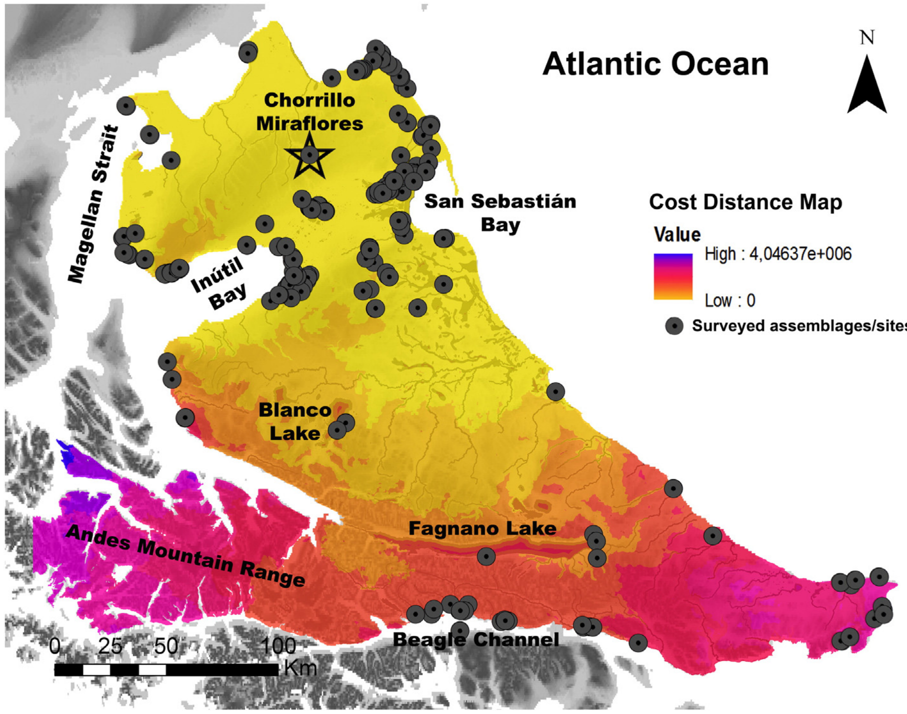

Fig. 3. Multi-criteria cost distance map from Chorrillo Miraflores source based on walking across the landscape and the distribution of surveyed sites within Isla Grande de Tierra del Fuego.

access is integrated with routes beginning in two sites located on the northern coast of Inútil Bay which cross Boquerón Ranges and descend to the source. It is worth mentioning that one of the sites, located <3 km from the other, connects with Miraflores source by its headwaters.

Beyond the hills surrounding the Chorrillo Miraflores Valley, the alternatives of optimal pathways increase in the northern steppe. Several possible routes connect sites on the coast of the Strait of Magellan, Inútil Bay, the Atlantic coast, and San Sebastian Bay with the source. In general, the pattern is characterized by independent paths throughout the northern plains, with only sporadic contacts with various water bodies. Only a few routes have small stretches running by particular landforms such as stream margins and portions of the coastal plain adjacent to San Sebastián and Inútil Bays.

In contrast, pathways connecting central and southern sites (Lago Blanco, Kami, Bahía Valentín, San Pablo) with the source are concentrated in the eastern half of the Island, and they are a continuation of paths previously selected by the LCP model for sites located near San Sebastián Bay. One pathway is mainly coastal and ensures the optimal dispersion of Miraflores tuff to San Pablo locality. The other pathways make possible the dispersion of silicified tuff towards southern archaeological sites such as Lago Blanco, Kami, and Bahía Valentín. The latter mostly pass along river valleys of the forest-steppe ecotone and the forest.

In general, the optimal pathways in the central and southern parts of the islandscape are closely associated with particular landforms. Despite the low number of cases recorded, the movement pattern strongly relies on river valleys and the maritime coast. Thus, the distribution of Miraflores rocks within the south of Isla Grande may have been primarily confined to a few main pathways. This southern trend differs significantly from the mobility pattern registered across the northern steppes.

The model also found optimal pathways through southwestern island, but they connect sites without Miraflores rocks to the west of Fagnano Lake and on the Beagle Channel. This trend emphasizes the importance of the eastern part of the islandscape in the dispersion of Miraflores raw materials towards the center and south of the Isla Grande. Finally, to the western edge of the island, there is only one assemblage with Miraflores artifacts, whose pathway converges with routes initiated from sites within the central coast of Inútil Bay. The results from the LCP model suggest that San Sebastián and Inútil Bays may have been important nodes in the distribution networks of Miraflores raw materials along the islandscape in the past.

4.2. Spatial distribution

The null hypothesis of independence between landform and types of sites can be rejected, because the value of Chi^2 is significant ($Chi^2 = 24.287$, $p = 0.0004624$). In particular, sites with Miraflores silicified tuff are the most commonly registered in rock outcrops and tertiary deposits, while they are less frequent than expected in marine landforms (Fig. 6). Standardized residuals for sites without Miraflores raw materials and others with Miraflores tuff are not significant. Nevertheless, the test indicates that the former are located mainly in marine deposits and the latter are more common in lacustrine deposits.

With regards to the relationship between types of sites and environments, Chi^2 is also significant ($Chi^2 = 7.563$, $p = 0.02279$). So, the null hypothesis of independence between them can be rejected. But the Chi^2 test does not show significant standardized residuals. However, trends agree with previous Chi^2 test (Fig. 7). Sites with Miraflores silicified tuff are the most commonly registered inland, where most of the tertiary deposits and rock shelters are located. Sites without Miraflores raw materials are more common on the coast while sites with Miraflores tuff distribute similarly on the coast and inland.

5. Discussion

The LCP model indicates that there are different movement patterns between the north and south of the Isla Grande de Tierra del Fuego. Such differences could reflect different forms of Miraflores raw material procurement (direct or indirect) between populations that occupy both spaces, also including an unequal dependence on social interactions. In the north of the Island, multiple different pathways are possible due to the permeability of the Fuegian steppe. Least-cost paths independently access the lithic source from different areas along the Strait of Magellan as well as San Sebastián and Inútil Bays. Within this landscape, Fuegian

Table 1
Assigned cost values of reclassified variables.

Slopes (degrees)	Value	Water source	Value	Vegetation	Value
0–10	1	Buffer areas (0. 5 km along margins of rivers, lakes and lagoon)	1	Steppe and bare land	1
10–20	10	Rivers (permanent and temporary)	10	Open steppe shrubs	10
20–30	20	lakes and lagoons (permanent and temporary)	100	Forest-steppe ecotone	20
30–40	50	–		Ecotone with closed shrubs	50
>40	100	–		Deciduous, mixed evergreen forests	100

Table 2
Frequency of archaeological assemblages/sites surveyed in Isla Grande de Tierra del Fuego by landform and environment. References: Miraflores raw materials (MR), Miraflores tuff (RT) and Miraflores silicified tuff (ST).

	Landform				Environment	
	Marine	Fluvial	Rock outcrops/Tertiary	Lacustrine	Coast	Interior
Sites with Miraflores RT	13	0	1	10	13	11
Sites with Miraflores ST	10	8	12	10	14	24
Sites without Miraflores RM	114	35	24	48	134	87

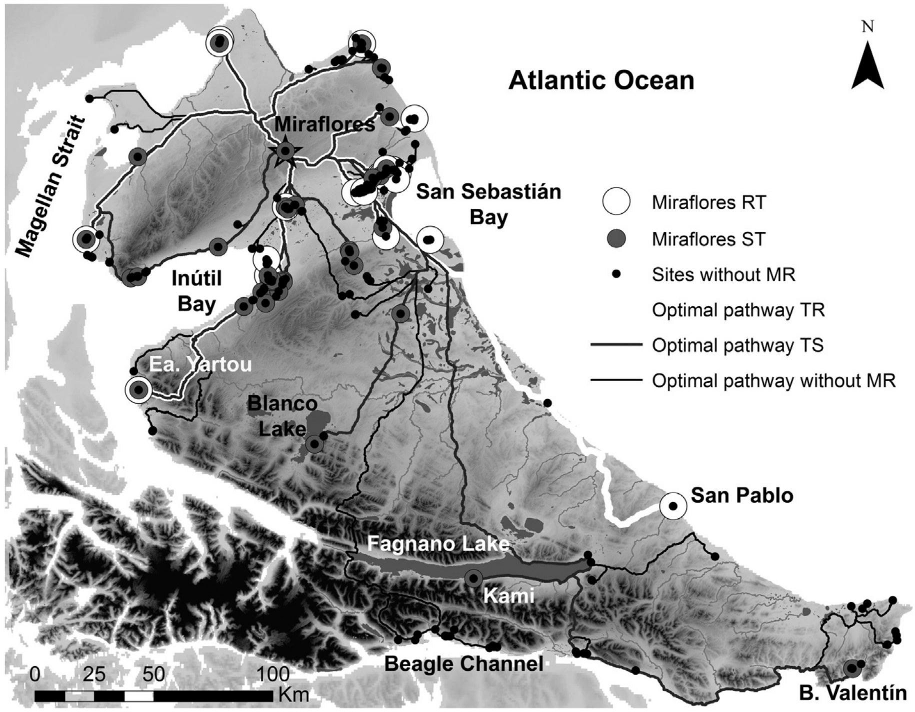

Fig. 4. Optimal pathways from sites to source. Circles indicate sites without Miraflores raw materials (MR), with tuff (RT) and silicified tuff (ST); lines depict their optimal pathways to the Chorrillo Miraflores.

groups could move easily between different zones, making strategic choices from the array of possible connective pathways. This means that the exploitation of Miraflores source would have been integrated to relatively autonomous lithic procurement strategies among groups of northern island during the Late Holocene, and thus acquisition process may have been little dependent on social interaction networks. However, the hills surrounding Miraflores source appear as a constraining factor, which gives priority to the northern headwathers and the southern mouth of the Chorrillo Miraflores Valley to access the lithic source. But given the lack of marked territoriality among Fuegians, even during historic times (Gusinde, [1937] 1982; Chapman, 1986), we believe that the two primary pathways to access the source could be part of a space of communal use among northern groups, without affecting their independence in Miraflores procurement strategies.

In contrast to the north, the spatial patterning in central-south Isla Grande is more restricted to a few pathways through river valleys and coastlines, especially as the forest becomes closed. Pathways often overlap in these locations and, moreover, they share similar placement logic to trails born in northern bays of the Island: Blanco Lake, Fagnano Lake and Valentín Bay with San Sebastián Bay; Puerto Arthur with Inútil Bay. This movement pattern is congruent with the high occupational redundancy recorded in both northern bays, which also yield the assemblages exhibiting the highest relative frequencies of Miraflores rocks of the island. With this qualitative assessment supporting the GIS model, the results of the analysis highlight the importance of connections with archaeological sites located on northern bays for the distribution of Miraflores rocks at the regional scale. It also suggests some important aspects about the nature of interactions between human populations in northern coastal areas and the central-southern islandscape. Jointly, these data support the existence of procurement strategies for Miraflores lithologies among central and southern populations characterized by a more dependent movement on a few pathways. This could imply Miraflores acquisition may have strongly relied on social interaction networks, particularly associated with coastal populations of San Sebastián and Inútil Bays.

A common pattern to most sites with artifacts manufactured from Miraflores raw material is that they are located >20 km from the source (except Miraflores 1, located within the procurement area, Prieto et al., 2004) and average 52.6 km within the 100 km radius of the source. The remaining five sites average 196 km and are between 115 and 320 km from the Chorrillo Miraflores Valley. In terms of territorial dynamics, the spatial pattern has no clear meaning, although we believe that it marks the extent of regularly connected spaces with the source in approximately the first 50 km. Some differences in mechanism of accessing the source may have emerged among Fuegian populations within the 50 km and 100 km radius area since these spaces seem to have a more restricted access to the Miraflores Valley and/or its raw materials. For the central and southern island, it is clear that people would have most likely obtained Miraflores rocks as part of 'visits' to other groups or other mechanisms of open social formations. In other words, people moving without specific purposes of trading, but whose actions may generate incidental depositions of goods outside their usual home range (Borrero et al., 2011; Pallo and Borrero, 2015).

Nevertheless, the recorded distances exceed the possibilities of daily logistical moves in general (Kelly, 1995; Binford, 2001). Rather, provisioning strategies (direct or indirect), should have involved trips of at least two days. In particular, the routes among central-southern sites with Miraflores rocks and each cluster of sites in the north of the island do not pass close to any known intermediate archaeological sites with Miraflores rocks. These intermediate sites could be used to break up the journey or stay overnight. However, under periods of climatic stress, it is possible that optimal areas may become more intensively used, possibly acting like 'refugia' while less optimal areas and intermediate archaeological sites are abandoned or less frequently used, especially in the southern half of the Island. This may have significantly affected the movement pattern, equate with shorter trips rather than longer, due to an increased risk of longer trips.

In this regard, human movement could have been altered by major climatic changes (PEH and ACM) or the expansion of forest environments after 1500 BP (Heusser, 1993; Pallo and Ozán, 2014), including possible episodes of reduced connection between the north and south of the island. Additionally, there are cultural factors beyond optimality which probably increase variability in mobility patters of prehistoric hunter-gatherers. It is clear that the pathways modelled here are only an optimal alternative of many possible renditions on the past. In this sense, our model provides a way of exploring general tendencies about the possibilities offered by different environmental units of the island for human movement, rather than skewing our vision on a strict pattern of human behavior.

5.1. Miraflores rocks and the use of space

The results of the Chi^2 test are useful to characterize the exploitation of Miraflores rocks, correlating technological trends observed on both lithologies and the use of spaces. In this regard, Chi^2 test indicates that sites with artifacts manufactured from silicified tuff ($n = 35$) show higher frequencies of rock outcrops within the interior Fuegian steppe. According to their low density and diversity of artifact, these archaeological deposits may have resulted from circumstantial use (Urrejola Dittborn, 1971, Massone, 1997; Morello et al., 2009), playing a minor role within the occupational hierarchy of the Fuegian steppe (Pallo, 2012a). Therefore, the use of silicified tuff end-scrapers may be interpreted within a framework of logistic mobility and strategies of provisioning individuals (sensu Kuhn, 2004). The macroregional homogeneity recorded in the (small) size (mean length = 20 mm) and edge angle (80°) suggest a global standard for the discard of Miraflores silicified tuff end-scrapers (Borrazzo et al., 2015). In terms of landform categories registered among sites, the variability of situations where the silicified tuff is recorded also supports this idea.

In contrast, frequencies of sites with tuff artifacts ($n = 25$) are similar in coastal and inland environments. In addition, these kinds of sites are mostly in coastal dunes in the north of the Island and the lagoon margins near San Sebastián Bay. The latter were defined as scheduled use areas within the framework of logistic strategies (and the provisioning of places in some cases), probably because they are locales that concentrate faunal and lithic resources (Borrazzo, 2010; Pallo, 2012a).

Although these patterns are not conclusive, by combining the archaeological distributions of raw materials from a known local source and least coast pathway analyses, we begin to propose possible travel routes inferred from reasonable criteria. The power of this methodological combination allows moving away our behavioral reconstructions from sourcing studies limitations due to instrumental analysis which only provides the potential distance and direction of transport/movement (Renfrew, 1977; Meltzer, 1989; Feblot-Augustins, 1993; Brantingham, 2003, 2006). In addition, the differences highlighted on Miraflores rocks distribution and landforms/environments are a first step towards defining behavioral trends within a logistical component and the heterogeneous role of different landscape units in occupational ranking of Fuegian hunter-gatherers.

5.2. The role of maritime people in Miraflores rocks distribution

Since Miraflores rocks were recovered from archaeological sites of canoe populations as well (Labarca et al., 2014; Borrazzo et al., 2015), our study also assessess the participation of canoe groups in the distribution of Miraflores raw materials at different scales: within the Isla Grande and the wider Fuegian Archipelago. Water has the potential to reduce traveling times between sites, even if distances increase. The travel pathways between sites can be re-modelled whenever water is navigable by canoe. Therefore the evidence from this case study can highlight alternative routes and pathways along which interaction may have occurred.

The use of canoe probably involved navigating close to the coast to minimize the effects of marine currents (Legoupil, 2000). Based on coastal geomorphology and Fuegian Archipelago hydrodynamic, the most dangerous areas for canoe navigation would have been in the open sea (i.e. outer borders of Fuegian Archipelago as well as Pacific and Atlantic mouths of the Strait of Magellan). By contrast, interior sounds and the medial portion of the Strait would have offered better conditions for this kind of navigation (Pallo, 2011). Historical sources also mention the complementary terrestrial circulation of canoe people through natural paths (named *paso de indios*) which allowed crossing biogeographic barriers and reducing travel time (Borrero, 2001). Circulating through *pasos de indios* involved movements by canoe to certain locations from where journey continued on foot (Emperaire, 1963; Emperaire and Laming, 1961; Legoupil, 2000; Prieto Iglesias et al., 2000).

At the scale of Isla Grande, canoe navigation complemented with the use of natural paths in solid ground may explain the scarcity of Miraflores rocks in Fagnano Lake and Beagle Channel areas. According LCP model, Almirantazgo-Fagnano Strait represents an optimal path; however, this path was included within the routes connecting Beagle Channel sites which do not exhibit Miraflores raw materials. Historical and archaeological evidence of *Kawéskar* (maritime people of western Archipelago) camps on the western coasts of the island (Emperaire, 1963; Legoupil et al., 2011) supports the hypothesis that the 10 km strait connecting Almirantazgo Sound with western margin of Fagnano Lake could have constituted a *paso de indios* (Fig. 5).

By contrast, southern Fuegian sites with Miraflores artifacts, like Kami 1 (De Ángelis and Mansur, 2015) and Bahía Valentín site 11 (Zangrando et al., 2012), are connected with Chorrillo Miraflores source only through optimal pathways derived from eastern portion of the island. Thus, the model indirectly suggests that the transportation of Miraflores rocks did not require the participation of maritime groups (entering the island through Almirantazgo Sound and following the Strait/Azopardo River basin to reach the western margin of Fagnano Lake) to circulate and distribute towards the south of Isla Grande de Tierra del Fuego. The dispersal of these raw materials towards central-southern sites would have relied primarily on connections with eastern half of the Island. Additionally, technological information provided by Fuegian lithic collections highlighted that the strategies of exploitation and use of both Miraflores raw materials are similar at the macro regional scale, alluding to the existence of common patterns shared by one large or several smaller populations (Borrazzo et al., 2015).

With regards to the wider scale of Fuegian Archipelago, the minimum frequencies of Miraflores raw materials on Magdalena (Labarca et al., 2014) and Offing (Langlais, 2016) Islands as well as at Laredo Bay on the continental coast of the Strait of Magellan (Borrazzo et al., 2015), certainly suggest that canoe people knew these rocks. Therefore, the presence of Miraflores raw materials in the middle section of the Strait of Magellan (named Paso Ancho), which was a main waterway to establish interaction between canoe people and terrestrial hunter-gatherers of the Fuegian steppes (Pallo, 2011), seem to show that this sector would also provide a better picture on the degree of inter-island transport of Miraflores rocks.

Archaeological and historic sources suggest that the usual maritime group home ranges were located on the western border of Patagonian-Fuegian islands (Ortiz Troncoso, 1975; Martinic, 1989; Legoupil, 2000; Morello et al., 2004). According to historic documents, contacts between kawéskar groups from the Fuegian Archipielago and selk'nam from Isla Grande de Tierra del Fuego were established on the northwestern portion of Isla Grande, especially on Inútil Bay, while other southwestern spaces (such as Almirantazgo Sound) were included in kawéskar itinerary but without including contacts with terrestrial hunter-gatherers (Gusinde, [1937] 1982). All this information is hitherto in agreement with the hypothesis that Miraflores rocks dispersal inland should have been integrated exclusively within mobility circuits of terrestrial groups.

At this point of the discussion it is also relevant to summarize the information provided by one of the two exotic (offshore) lithic raw materials recorded in Fuegian lithic assemblages: Otway-Riesco green obsidian, a rock controlled by western maritime hunter-gatherers (Morello et al., 2004). Green obsidian artifacts in terrestrial hunter-gatherer sites of Isla Grande are scarce (see Morello et al., 2012). However, these findings indicate contact with canoe groups from central

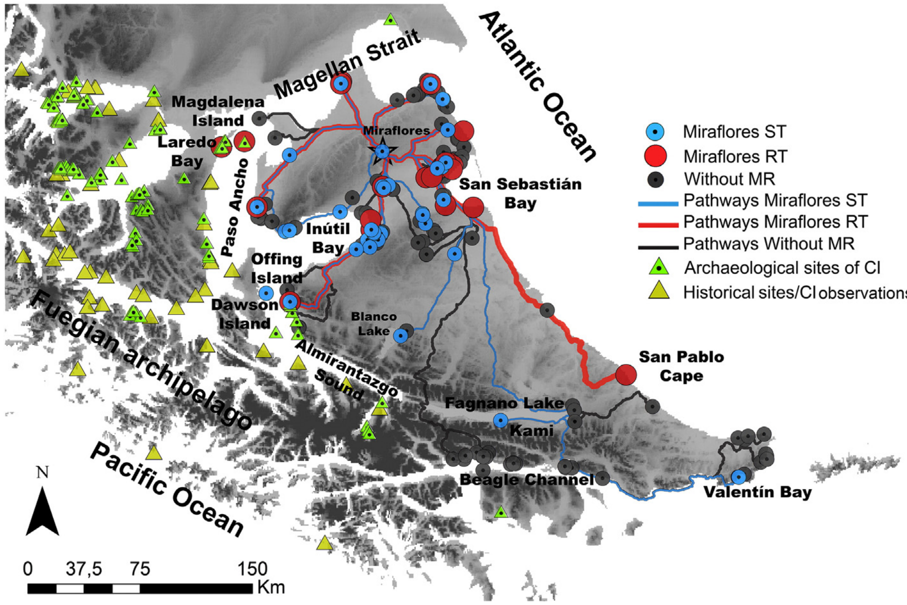

Fig. 5. Mosaic plot of contingency table. Residuals bigger than two can be considered significant at $\alpha = 0.05$. Blue columns: more site types by landforms than expected by chance. Pink columns: less site types by landforms than expected by chance. References: MST: Miraflores silicified tuff; MRT: Miraflores tuff; MR: Miraflores raw materials.

Strait of Magellan, where Miraflores rocks were also transported (Offing and Magdalena Islands, and Bahía Laredo).

Large-scale contacts among maritime hunter-gatherers from Strait of Magellan-Otway Sound and Beagle Channel are known since ca. 6500–6000 BP (sensu Álvarez, 2004; Morello et al., 2004). However, by the Late Holocene, green obsidian is limited in distribution to the central portion of Isla Grande, indicating a close connection between Inútil Bay and eastern lagoon environments. According to LCP model, lagoon environments would also be the optimal route for Miraflores rocks dispersal towards the centre and south of the island. However, by the time green obsidian become limited in archaeological distribution, Miraflores rocks widely appear within archaeological sites from north to south of the Isla Grande. In this context, Inútil Bay records the highest relative frequency of artifacts manufactured on Miraflores rocks and green obsidian, highlighting that the bay would have been a primary scenario for terrestrial and canoe population interaction, at least since the Late Holocene (Gusinde, [1937] 1982). Further archaeological research will allow to adjust timing and variability of the interaction between terrestrial and canoe people, and assessing if green obsidian provisioning within Isla Grande de Tierra del Fuego was altered by the regional exploitation of Miraflores raw materials during the Late Holocene.

6. Conclusions

The LCP model, the distributional analysis, and the interpretations posited in this paper contribute to the archaeology of Tierra del Fuego during the Late Holocene at several levels. At the regional scale, it suggests that independent trails and multiple access points to the Miraflores source from different spots in the north of the island existed. On the contrary, the distribution pattern of Miraflores raw material to the southern Island may have probably relied on a few selected

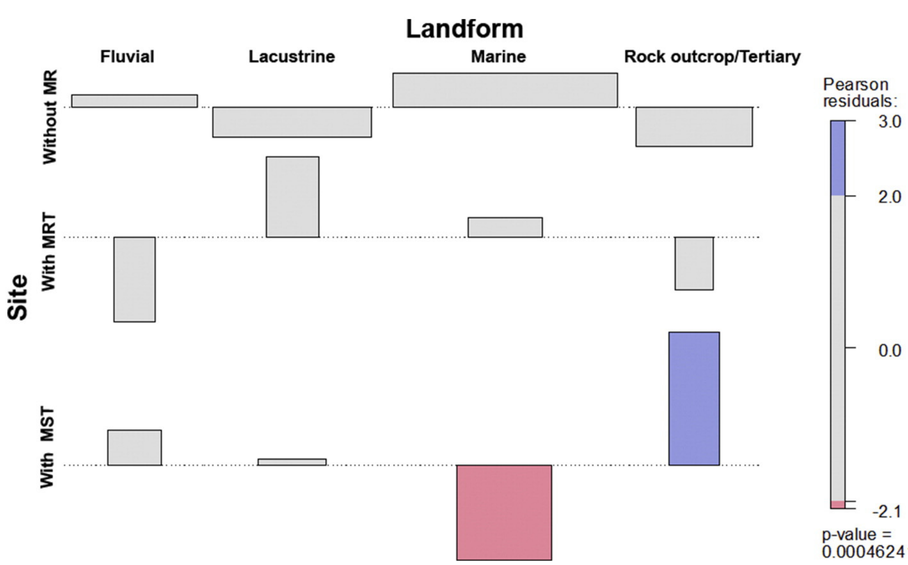

Fig. 6. Mosaic plot of contingency table. Residuals bigger than two can be considered significant at $\alpha = 0.05$.References: MST: Miraflores silicified tuff; MRT: Miraflores tuff; MR: Miraflores raw materials.

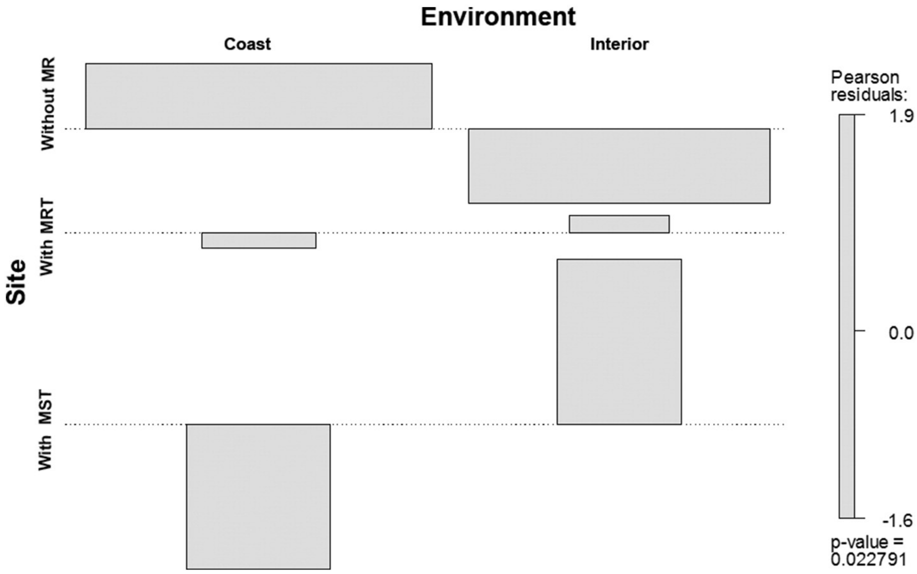

Fig. 7. Spatial information about archaeological sites and optimal pathways in Isla Grande de Tierra del Fuego. It includes archaeological sites, and spots where Canoe Indians were observed during historic times (Martinic, 1989; Morello et al., 2004). References: ST: silicified tuff; RT: Miraflores tuff; MR: Miraflores raw materials.CI: Canoe Indians.

pathways related to archaeological localities for both the Inútil and San Sebastián Bays. This indicates that populations settled south of the Isla Grande drew heavily on social interaction for Miraflores raw materials supply. The LCP model also suggests that the procurement of Miraflores rocks within Isla Grande de Tierra del Fuego may have managed without canoe mobility and therefore their circulation remained under the sole control of terrestrial hunter gatherers. This pattern resembles that of Otway-Riesco green obsidian, which would have been extracted and distributed by maritime people.

At a larger scale, the transport of Miraflores rocks out of the island would have required canoe navigation (Labarca et al., 2014; Langlais, 2016). Inútil Bay could have a central role in the exchange of Miraflores or other goods between terrestrial and marine human groups, although it seems their frequency was always very low (Morello et al., 2012). Away from the source, systems of visits allow explaining Miraflores raw materials within northern landscape, due to highly interconnected spaces without territorial limits clearly defined. Visits and the lack of territoriality also would explain the current distribution of most allochthonous items within Isla Grande, resembling the modes of social interaction among hunter-gatherers of southern mainland Patagonia (Borrero et al., 2011; Pallo and Borrero, 2015).

Acknowledgments

We are extremely grateful to the anonymous reviewers. Their thorough reading and insightful comments improve the final version of this paper. We also thank the following people and institutions for granting access to projectile point collections: Museo del Fin del Mundo and Centro Austral de Investigaciones Científicas (Ushuaia, Argentina); Museo Regional de Magallanes and Centro de Estudios del Hombre Austral (Punta Arenas, Chile); Museo Etnográfico "Juan Bautista Ambrosetti", Instituto de Antropología and Instituto Multidisciplinario de Historia y Ciencias Humanas (Buenos Aires, Argentina); Museo de la Patagonia "Francisco P. Moreno" (San Carlos de Bariloche, Argentina); Museo Regional Provincial "Padre Manuel Jesús Molina" (Río Gallegos, Argentina); Centro Nacional Patagónico (Puerto Madryn, Argentina); Museo Histórico Municipal de San Antonio Oeste (San Antonio Oeste, Río Negro); L.A. Borrero, P. Campan, P. Cárdenas, N. Franco, J. Gómez Otero,P. Grendi, J.L. Lanata, M. Massone, F. Morello, L.A. Orquera, C. Otzen, N. Perez, E. Piana, A. Prieto, N. Ratto, M. San Román, L. Sosa, M. Vázquez, M. Weissel, A. F. Zangrando, A. Reynoso, M. Marchegiani and R.D. Koch. Marcelo Cardillo is specially thanked for helping with statistical analyses. This research was funded by ANPCyT (PICT 2011-2317) and CONICET (PIP-11220110100262, directed by L.A. Borrero).

References

Allué, C., Arranz, J., Bava, J., Beneitez, J., Collado, L., García-López, J.M., 2010. Caracterización y cartografía fitoclimáticas del bosque nativo subantártico en la Isla Grande de Tierra del Fuego (Patagonia, Argentina). For. Syst. 19 (2), 189–207.
Álvarez, M., 2004. ¿a qué Responde la Diversidad Instrumental? Algunas Reflexiones a Partir del análisis Funcional de Materiales líticos de la Costa Norte del Canal Beagle. In: Civalero, M.T., Fernández, P.M., Guraieb, A.G. (Eds.), Contra Viento Y Marea. Arqueología de Patagonia. INAPL and SAA, Buenos Aires, pp. 29–43.
Andrefsky, W., 1994. Raw material availability and the organization of technology. Am. Antiq. 59, 21–34.
Aragón, E., Franco, N., 1997. Características de rocas para la talla por percusión y propiedades petrográficas. An. Inst. Patagonia. 25, 187–199.
Beck, C., Taylor, A., Jones, G., Fadem, C., Cook, C., Millward, S., 2002. Rocks are heavy: transport costs and Paleoarchaic quarry behavior in the Great Basin. J. Anthropol. Archaeol. 21, 481–507.
Binford, L., 2001. Constructing Frames of Reference. AnAnalytical Method for Archaeological Theory BuildingUsing Ethnographic and Environmental Data Sets. University of California Press, California.
Bird, D.W., O'Connell, J.F., 2006. Behavioral ecology and archaeology. J. Archaeol. Res. 14, 143–188.
Borrazzo, K.B., 2009. El Uso prehistórico de Los Afloramientos Terciarios en la bahía San Sebastián (Tierra Del Fuego, Argentina). In: Salemme, M., Santiago, F., Álvarez, M., Piana, E., Vázquez, M., Mansur, M. (Eds.), Arqueología de Patagonia: Una Mirada Desde El último confín. Editorial Utopías, Ushuaia, pp. 291–305.
Borrazzo, K.B., 2010. Arqueología de los esteparios fueguinos. Tafonomía lítica y tecnología en el norte de Tierra del Fuego Unpublished doctoral dissertation Facultad de Filosofía y Letras, Universidad de Buenos Aires.
Borrazzo, K., 2012. Raw material availability, flaking quality and hunter-gatherer decision making in northern Tierra Del Fuego Island (Argentina). J. Archaeol. Sci. 39, 2643–2654. http://dx.doi.org/10.1016/j.jas.2012.03.018.
Borrazzo, K., D'Orazio, M., Etchichury, M.C., 2010. Distribución espacial y uso prehistórico de las materias primas líticas del chorrillo Miraflores en el norte de isla Grande de Tierra del Fuego (Argentina). Rev. Chil. Antropol. 22, 77–97.
Borrazzo, K., Martin, F.M., Barberena, R., Borrero, L.A., 2008. Geografía cultural y circulación humana en el norte de Tierra del Fuego. In: Borrero, L.A., Franco, N.V. (Eds.), Arqueología del extremo sur del continente Americano. CONICET-IMHICIHU, Buenos Aires, pp. 227–249.
Borrazzo, K., Morello, F., Borrero, L.A., D'Orazio, M., Etchichury, M.C., Massone, M., De Ángelis, H., 2015. Caracterización y uso de las materias primas líticas de Chorrillo Miraflores en el extremo meridional de Fuego-Patagonia. Intersecciones Antropol. 16 (1), 155–167.
Borrazzo, K., Pallo, M.C., 2015. Geoquímica, SIG y Arqueología: uso del espacio y circulación humana en Tierra del Fuego durante el Holoceno tardío. Territorios memorias e identidad Actas de las IV Jornadas Interdisciplinarias. CONICET-IMHICIHU, Buenos Aires (in press).
Borrero, L.A., 2001. El poblamiento de la Patagonia. Toldo, milodones y volcanesEmecé Editores, Buenos Aires.
Borrero, L.A., Martin, F., Barberena, R., 2011. Visits, "Fuegians", and information networks. In: Whallon, R., Lovis, W., Hitchcock, R. (Eds.), Information and its Role in Hunter-Gatherer Bands. University of California Press, L.A., pp. 249–269.

Borromei, A.M., Coronato, A., Franzén, L.G., Ponce, J.F., López Sáez, J.A., Maidana, N., Rabassa, J., Candel, M., 2010. Multiproxy record of Holocene paleoenvironmental change, Tierra del Fuego,Argentina. Palaeogeogr. Palaeoclimatol. Palaeoecol. 286, 1–6.
Bridges, T., 1878. Los indios del último confín. Zagier & Urruty, Buenos Aires.
Brantingham, P.J., 2003. A Neutral Model of Stone Raw Material Procurement. Am. Antiq. 68, 487–509.
Brantingham, P.J., 2006. Measuring Forager Mobility. Curr. Anthropol. 47, 435–459.
Bujalesky, G.G., 2007. Coastal geomorphology and evolution of Tierra del Fuego (Southern Argentina). Geol. Acta 5 (4), 337–362.
Cardillo, M., Alberti, J., 2013. Raw material availability and distribution, and human exploitation strategies in coastal North Patagonia, Río Negro province, Argentina. Poster presented in the 5th Arheoinvest Symposium "Stories Written in Stone"International Symposium on Chert and Other Knappable Materials.AIC University, Iasi, Romania.
Chambers, F.M., Brain, S.A., Mauquoy, D., McCarroll, J., Daley, T., 2014. The little ice Age'in the Southern Hemisphere in the context of the last 3000 years: peat-based proxy-climate data from Tierra del Fuego. The Holocene 24 (12) (0959683614551232).
Chapman, A., 1986. Los Selk'nam. La vida de los Onas. Emecé, Buenos Aires.
Charlin, J.E., 2009. Estrategias de aprovisionamiento y utilización de las materias primas líticas en el campo volcánico Pali Aike (provincia de Santa Cruz, Argentina). BAR Reports - Archaeopress, Cambridge.
Clarkson, C., Bellas, A., 2014. Mapping stone: using GIS spatial modelling to predict lithic source zones. J. Archaeol. Sci. 46, 324–333.
Codignotto, J., Malumian, N., 1981. Geología de la región al norte del paralelo 54° S de la Isla de Tierra delFuego. Rev. Asoc. Geol. Argent. XXXVI (1), 44–88.
Conolly, J., Lake, M., 2006. Geographical Information Systems in Archaeology. Cambridge University Press, Cambridge.
Coronato, F., 1993. Wind chill factor applied to Patagonian climatology. Int. J. Biometeorol. 37, 1–6.
Coronato, A., 2014. Territorios Fueguinos: fisonomía, Origen, evolución. In: Oría, J., Tívoli, A. (Eds.), Cazadores de mar y de tierra,estudios recientes en arqueología fueguina. Museo del fin del mundo, Ushuaia, pp. 43–63.
Clapperton, C.M., 1992. La última glaciación y deglaciación en el estrecho de Magallanes: implicaciones para el doblamiento de Tierra del Fuego. An. Inst. Patagonia 21, 113–128.
De Ángelis, H., 2012. Materias primas lejanas. Explotación de recursos líticos no locales para la confección de micro-raspadores en el centro de tierra del fuego: el caso arqueológico Kami. Magallania 40 (2), 247–257.
De Ángelis, H., Mansur, M.E., 2015. Exploitation of allochthonous raw materials in hunter-gatherer contexts: archaeological sites of Fagnano Lake, Tierra del Fuego, Argentina. Quat. Int. 375, 124–134.
Dijkstra, E.W., 1959. A note on two problems in connection with graphs. Numer. Math. 1, 269–271.
Emperaire, J., 1963. Los nómades del mar. Ediciones de la Universidad de Chile, Santiago de Chile.
Emperaire, J., Laming, A., 1961. Les Gisements des iles Englefield et Viviam dans la mer d'Otway (Patagonia Australe). Journal de la Societe des Americanistes 50, 7–77.
Feblot-Augustins, J., 1993. Mobility strategies in the late middle Palaeolithic of Central Europe and Western Europe: elements of stability and variability. J. Anthropol. Archaeol. 12, 211–265.
Franco, N.V., 2002. Estrategias de utilización de recursos líticos en la cuenca superior del río Santa Cruz (Argentina) Unpublished PhD thesis Facultad de Filosofía y Letras, Universidad de Buenos Aires.
Franco, N., 2014. Lithic artifacts and the information about human utilization of large areas. In: Escola, P., Hocsman, S. (Eds.), Artefactos Líticos, Movilidad y Funcionalidad de Sitios: Problemas y Perspectivas. BAR Reports, Oxford, pp. 117–127.
Frederiksen, P., 1988. Soils of Tierra del Fuego. A satellite based Land Survey Approach. Folia Geogr. Dan. XVIII, 159.
Gallardo, C.R., 1910. Los onas de Tierra del Fuego. Zagier & Urruty Publications, Buenos Aires.
Gusinde, M., 1937. Los selk´nam. Los Indios de Tierra del Fuego. Centro Argentino de Etnología Americana, Buenos Aires.
Hammer, O., Harper, D., Ryan, R., 2001. PAST Palaeontological statistics software package for education and data analysis. Palaeontol. Electron. 4 (1), 9.
Haury, C.E., 1995. Defining lithic procurement technology. In: Church, T. (Ed.), Lithic Resources Studies: A Source Book for Archaeologist Vol. 3. Lithic Technology, Special Publication, Department of Anthropology, University of Tulsa. Tulsa, pp. 26–31.
Heusser, C., 1993. Late quaternary forest-steppe contact zone, Isla Grande de Tierras del Fuego, Subantarctic South America. Quat. Sci. Rev. 12 (3), 169–178.
Howey, M.C.L., 2007. Using multi-criteria cost surface analysis to explore past regional landscapes: a case study of ritual activity and social interaction in Michigan, CE 1200–1600. J. Archaeol. Sci. 34 (11), 1830–1846.
Kelly, R., 1995. The Foraging Spectrum. Diversity in Hunter-Gatherer Lifeways. Smithsonian Institution Press, Washington, D.C.
Krebs, J.R., Davies, N.B., 1987. Natural Selection, Ecology, and Behavior. An Introduction to Behavioral Ecology. Blackwell Scientific Publications, Oxford, pp. 5–23.
Kuhn, S., 2004. Upper Paleolithic raw material economies at Ücagizli cave, Turkey. J. Anthropol. Archaeol. 23, 431–448.
Kvamme, K.L., 1999. Recent directions and developments in geographical information systems. J. Archaeol. Res. 7 (2), 153–201.
Labarca, R., Prieto, A., Sierpe, V., Morano, C., 2014. Ocupaciones e intercambio en las islas orientales del estrecho de Magallanes: resultados preliminares. Poster presented in the IX Jornadas de Arqueología de la Patagonia. Coyhaique, Chile.
Langlais, M., 2016. El equipamiento y las producciones líticas. El sitio Offing 2, locus 1 (estrecho de Magallanes), directed by D. Legoupil. MS.
Legoupil, D., 2000. El sistema socioeconómico de los nómades del mar de Skyring (Archipiélago de Patagonia). An. Inst. Patagonia 28, 81–119.
Legoupil, D., Christensen, M., Morello, F., 2011. Una encrucijada de caminos: el poblamiento de la isla Dawson (estrecho de Magallanes). Magallania 39 (2), 137–152.
Lothrop, S.K., 1928. The Indians of Tierra del Fuego. Museum of the American Indian. Heye Foundation, New York.
Luckman, B., Villalba, R., 2001. Assessing the synchronicity of glacier fluctuations in the Western Cordillera of the Americas during the last millennium. In: Markgraf, V. (Ed.), Interhemispheric Climate Linkages. Academic Press, San Diego, pp. 119–140.
Luebert, F., Pliscoff, P., 2006. Sinopsis bioclimática y vegetacional de Chile. Editorial Universitaria, Santiago.
Martinic, M., 1989. Los canoeros de la Patagonia meridional. Población histórica y distribución geográfica (siglos XIX y XX). El fin de una etnia. Journal de la Société des Américanistes XXV, 35–61.
Martinic, M., 1995. Los aonikenk. Historia y cultura. Universidad de Magallanes, Santiago.
Massone, M., 1997. Prospección arqueológica del sector comprendido entre los ríos Marazzi y Torcido, zona norte de Tierra del Fuego. An Inst Patagonia 25, 123–136.
Massone, M., 2009. Territorios, movilidad y construcción de paisajes en el mundo selk´nam. In: Salemme, M., Santiago, F., Álvarez, M., Piana, E., Vázquez, M., Mansur, M. (Eds.), Arqueología de Patagonia: Una mirada desde el último confín. Editorial Utopías, Ushuaia, pp. 249–264.
Mauquoy, D., Blaauw, M., van Geel, B., Borromei, A., Quattocchio, M., Chambers, F., Possnert, G., 2004. Late Holocene climatic changes in Tierra del Fuego based on multiproxy analyses of peat deposits. Quat. Res. 61, 148–158.
McCulloch, R., Clapperton, C., Rabassa, J., Currant, A., 1997. The natural Setting. The glacial and Post-Glacial environmental history of Fuego-Patagonia. In: Mc Ewan, C., Borrero, L.A., Prieto, A. (Eds.), Patagonia. British Museum Press, London, pp. 12–31.
Meltzer, D., 1989. Was stone exchange among eastern north American Paleoindians? In: Ellis, C., Lothrop, J. (Eds.), Eastern Paleoindian Lithic Resource Use. Westview Press, Boulder, pp. 11–39
Moore, D.M., 1983. Flora of Tierra del Fuego. Anthony Nelson, Owestry.
Morello, F., San Román, M., Prieto, A., 2004. Obsidiana verde en Fuego-Patagonia: distribución y estrategias tecnológicas. In: Civalero, M.T., Fernández, P.M., Guraieb, A.G. (Eds.), Contra viento y marea. Arqueología de Patagonia. INAPL and SAA, Buenos Aires, pp. 149–166.
Morello, F., Borrero, L.A., Torres, J., Massone, M., Arroyo, M., McCulloch, R., Calás, E., Lucero, M., Martínez, I., Bahamonde, G., 2009. Evaluando el registro arqueológico de Tierra del Fuego durante el Holoceno temprano y medio: lo positivo de los balances negativos. In: Salemme, M., Santiago, F., Álvarez, M., Piana, E., Vázquez, M., Mansur, M. (Eds.), Arqueología de Patagonia: Una mirada desde el último confín. Editorial Utopías, Ushuaia, pp. 1075–1092.
Morello, F., Borrero, L.A., Massone, M., Stern, C., Garcia-Herbst, A., McCulloch, R., Arroyo Kalin, M., Calas, E., Torres, J., Prieto, A., Martínez, I., Bahamonde, G., Cárdenas, P., 2012. Hunter-gatherers, biogeographic barriers and the development of human settlement in Tierra del Fuego. Antiquity 86, 71–87.
Moy, C.M., Moreno, P., Dunbar, R., Francois, P., Kaplan, M., Villalba, R., Haberzettl, T., 2009. Climate change in southern South America during the last two millennia. In: Vimeux, F., Sylvestre, F., Khodri, M. (Eds.), Past Climate Variability in South America and Surrounding Regions: From the Last Glacial Maximum to the Holocene. Springer, Netherlands, pp. 353–393.
Nettle, D., Gibson, M.A., Lawson, D.W., Sear, R., 2013. Human behavioral ecology: current research and future prospects. Behav. Ecol. 34, 1031–1040.
Ocampo, C., Rivas, P., 1996. Caracterización arqueológica preliminar del suroeste de la Tierra del Fuego. An. Inst. Patagonia 24, 125–151.
Ortiz Troncoso, O., 1975. Los yacimientos de Punta Santa Ana y Bahía Buena (Patagonia Austral). Excavaciones y fechados radiocarbónicos. An. Inst. Patagonia 6 (1–2), 93–122.
Pallo, M.C., 2011. Condicionamientos de la dinámica ambiental en las decisiones humanas sobre asentamiento y circulación a lo largo el estrecho de Magallanes durante el Holoceno Tardío. Magallania 39 (2), 177–192.
Pallo, M.C., 2012a. Análisis biogeográfico sobre el uso humano del espacio en Magallania Unpublished doctoral dissertation Facultad de Filosofía y Letras, Universidad de Buenos Aires.
Pallo, M.C., 2012b. Uso del espacio y explotación de los rrecursos faunísticos en el norte de Tierra del Fuego durante el Holoceno Tardío: urn acercamiento desde los Sistemas de Información Geográfica (SIG). In: Kuperszmit, N., Lagos Mármol, T., Mucciolo, L., Sacchi, M. (Eds.), Entre Pasados y Presentes 3. Estudios contemporáneos en Ciencias Antropológicas. INAPL, Buenos Aires, pp. 980–999.
Pallo, M.C., Borrero, L.A., 2015. ¿Intercambio o movilidad?: una evaluación sobre el uso de escalas de análisis espaciales y curvas de decaimiento en Patagonia Centro-meridional (Argentina). Lat. Am. Antiq. 23 (6), 287–303.
Pallo, M.C., Ozán, I., 2014. Variaciones demográficas y climáticas durante el Holoceno tardío final en Magallania. Comechingonia Virtual VII 1, 20–47.
Popper, J., 1887. Atlanta. Eudeba, Buenos Aires.
Prieto, A., Cárdenas, P., Bahamonde, G., Massone, M., 2004. Hallazgo de una fuente de materia prima en el chorrillo Miraflores, Tierra del Fuego, Chile. Magallania 32, 229–232.
Prieto Iglesias, A., Chevallay, D., Ovando, D., 2000. Los pasos de indios en Patagonia Austral. Desde el país de los gigantes vol. I. UNPA, Río Gallegos, pp. 87–94.
Rabassa, J., Coronato, A., Bujalesky, G., Roig, C., Salemme, M., Meglioli, A., Heusser, C., Gordillo, S., Borromei, A., Quatrocchio, M., 2000. Quaternary of Tierra del Fuego, Southernmost South America: an updated review. Quat. Int. 68-71, 217–240.
Renfrew, C., 1977. Alternative models for exchange and spatial distribution. In: Earle, T., Ericson, J. (Eds.), Exchange Systems in Prehistory. Academic Press, New York, pp. 71–90.
Serrano Montaner, R., 1879. De la excursión a la isla Grande de la Tierra del Fuego durante los meses de enero y febrero de 1879 (Comp.) In: Martinic, M. (Ed.), Marinos de a

caballo. Exploraciones terrestres de la Armada de Chile en la Patagonia austral y la Tierra del Fuego 1877–1897. Editorial de la Universidad de Playa Ancha de Ciencias de la Educación, Valparaíso, pp. 173–222.
Stine, S., 1994. Extreme and persistent drought in California and Patagonia during mediaeval time. Nature 369 (6481), 546–549.
Taliaferro, M., Schriever, B., Shackleyc, S., 2010. Obsidian Procurement, Least Cost Path Analysis, and Social Interaction in the Mimbres Area of Southwestern New Mexico. J. Archaeol. Sci. 37, 536–548.
Tobler, W., 1993. Nonisopic Modeling. Three Presentations on Geographical Analysis and Modeling. National Center for Geographic Information and Analysis. Technical Report. Univ. of California, Santa Barbara 93–1.
Torrence, R. (Ed.), 1989. Time, Energy, and Stone Tools. Cambridge University Press, Cambridge.
Urrejola Dittborn, C., 1971. Isla Grande de Tierra del Fuego (Bahía Inútil). Informe Arqueológico. Boletín de Prehistoria de Chile 3 (4), 121–133.
Vidal, H., 1988. Bahía Valentín: 6000 años de ocupaciones humanas en el oriente fueguino. Libro de resúmenes del IX Congreso Nacional de Arqueología Argentina: 77. Facultad de Filosofía y Letras, Universidad de Buenos Aires, Buenos Aires.
Vilas, F., Arche, A., Ferrero, M., Isla, F., 1999. Subantarctic macrotidal flats, cheniers and beaches in San Sebastian Bay, Tierra del Fuego, Argentina. Mar. Geol. 160, 301–326.
Yesner, D., Figuerero Torres, M.J., Guichón, R.A., Borrero, L.A., 2003. Stable isotope analysis of human bone and ethnohistoric subsistence patterns in Tierra del Fuego. J. Anthropol. Archaeol. 22, 279–291.
Zangrando, A.F., Vázquez, M., Tessone, A. (Eds.), 2012. Los cazadores del extremo oriental fueguino. Arqueología de Península Mitre e Isla de los Estados. SAA, Buenos Aires.