# SOUTH AMERICA 18,000 YEARS AGO: TOPOGRAPHIC ACCESSIBILITY AND HUMAN SPREAD

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## Introduction

The entrance routes to the South American continent have been subject to debated theories along the twentieth century (i.e. Sauer 1944, Martin 1973) and they are still part of current discussions. Among the intervening factors analyzed in the diverse theoretic approaches to human mobility and dispersion are demographic considerations, paleoenvironmental conditions, the existence of natural barriers, the availability of resources which are useful for survival, and the technological variability. Some of the prevailing ideas can be resumed as those considering that population movements privileged a terrestrial advance strategy and those considering that population moved following the rivers and coastlines.

On the other hand, the models generated to date about the early American settlers consider different ways of living for these highly mobile groups, which can be summarized in terrestrial adaptations (Martin 1973) and water adaptations (Bryan 1978, Fladmark 1983, Meltzer 1993, Dixon 2000, Erlandson 2001). In the first ones, people movements privileged a terrestrial advance strategy and in the second, population moved following the rivers and coastlines (Miotti 2006).

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Methodologically, the modelling of possible routes have applied several views, such as anthropobiologic morphometric and DNA data (Meltzer 1993, O'Rourke and Raff 2010, Pucciarelli *et al*. 2003); demographic simulations (Gillam *et al.* 2007; Steele *et al*. 1998); and digital modelling of territorial analysis (Anderson and Gillam 2000).

The present paper is included in the last mentioned approach. The main goal of this work is to contrast two digital models of terrain accessibility generated for South America (Magnin et al., this volume) against a set of archaeological information on the earliest occupations. Both models have been produced to represent the main ideas prevailing for the ways of access to the continent (terrestrial vs. littoral and riverside), and the assessment of the best adjustment to either of them.

It is assumed that during the population process, the areas offering lower endeavour of access to humans were used before other naturally less accessible ones (Borrero 1995, Miotti 1998, 2006). People may have taken the most accessible paths, as land and coastal plains, and river banks, rather than those most strenuous, such as steep mountainous terrain, when moving through the landscape. It is also assumed that glacial masses acted as barriers to the general movements. The results will enable us to discuss if one of the models presents a better fit to the data, also to start evaluating its predictive potential, and finally to propose alternatives about the occupation process of the continent.

**Data, method and results**

The data employed include two digital models (Figure 1) and a set of georreferenced archaeological information. The models are two digital raster maps whose individual cells contain accessibility values. They were generated based on the estimated bathymetry for the span *ca.* 18,000 and 9000 RCYBP, the inland altitudinal values m a.s.l., and the glacial

extension (Magnin et al. 2010, this volume). The archaeological data include 30 sites with reliable contexts which are dated in more than 10,500 RCYBP, when glacial withdrawals and re-advances took place (see Rabassa 2008) (Figure 1).

The applied methodology involves the assignment of accessibility values from each model to every site, performing a value extraction using Zonal Statistics in GIS Spatial Analyst to obtain two value**s** distributions, one for each model (http://webhelp.esri.com/arcgisdesktop/9.2.). The values obtained are not the unique pixel value where the site is located, but the median value calculated from a 10 km buffer drowned at each site. This constitutes an assessment of the immediate surroundings of each site, trying to avoid possible errors due to the assignment of values given to a very small area unit. The resultant distribution of values (figure 2) shows that in model 1, most sites fit in the lowest accessibility value bin, while in model 2 the highest number of sites fit in the second defined bin.

**Discussion**

According to the expected pattern (sites should be located on areas with highest accessibility values) the results obtained indicate that data adjust better to model 2 than to model 1. Since it can be assumed that most of the coastal evidence from the earliest period is submerged today, it cannot be made sound inferences on the strict use of the coast, but the analyzed evidence could be showing a use of riversides in an intense way since the earliest chronologies. However, these results must be considered one first approach in the development and testing of the models. It was possible to detect trends in the data but it is not possible to rule out or confirm any of the theoretical models discussed. Furthermore, the models may not be mutually exclusive (Miotti 2006).

We consider that the development of these models is interesting as a way of analysis of archaeological data relating to early human occupations. They are attempts to bring complex patterns of mobility to digital maps that allow the analysis of spatial trends in the archaeological data. Future work will approach further testing which could lead to the consequent achievement of a better fit between the archaeological data and the models.

In the other hand, a deep theoretical discussion is launched. Although strong patterns of site locations existed, and the model had a high predictive value, it would not be exact to assume that the location of early sites is explained solely in terms of environmental variables (Kohler and Parker 1986). Instead, human choices should have followed different motivations.

**Final remarks**

In this paper, we sought to find patterns of differential mobility and use of concrete environments as a way to characterize the strategies employed by the first Americans.

The results favoured the model representing water adaptation strategies as the model which better fits the analyzed data (model 2). However, the current theoretic and methodological discussion shows that in the light of the great potentiality of the methods, and the complexity of the issue, none of the models can be rejected for the moment.

Future studies could incorporate more archaeological and environmental data of better synchronized chronology in order to analyze which areas were repetitively occupied, to evaluate possible changes adopted along time, and to add more information about how the spatial knowledge of the territory was built in the long peopling process of the South American continent.

**Acknowledgements**

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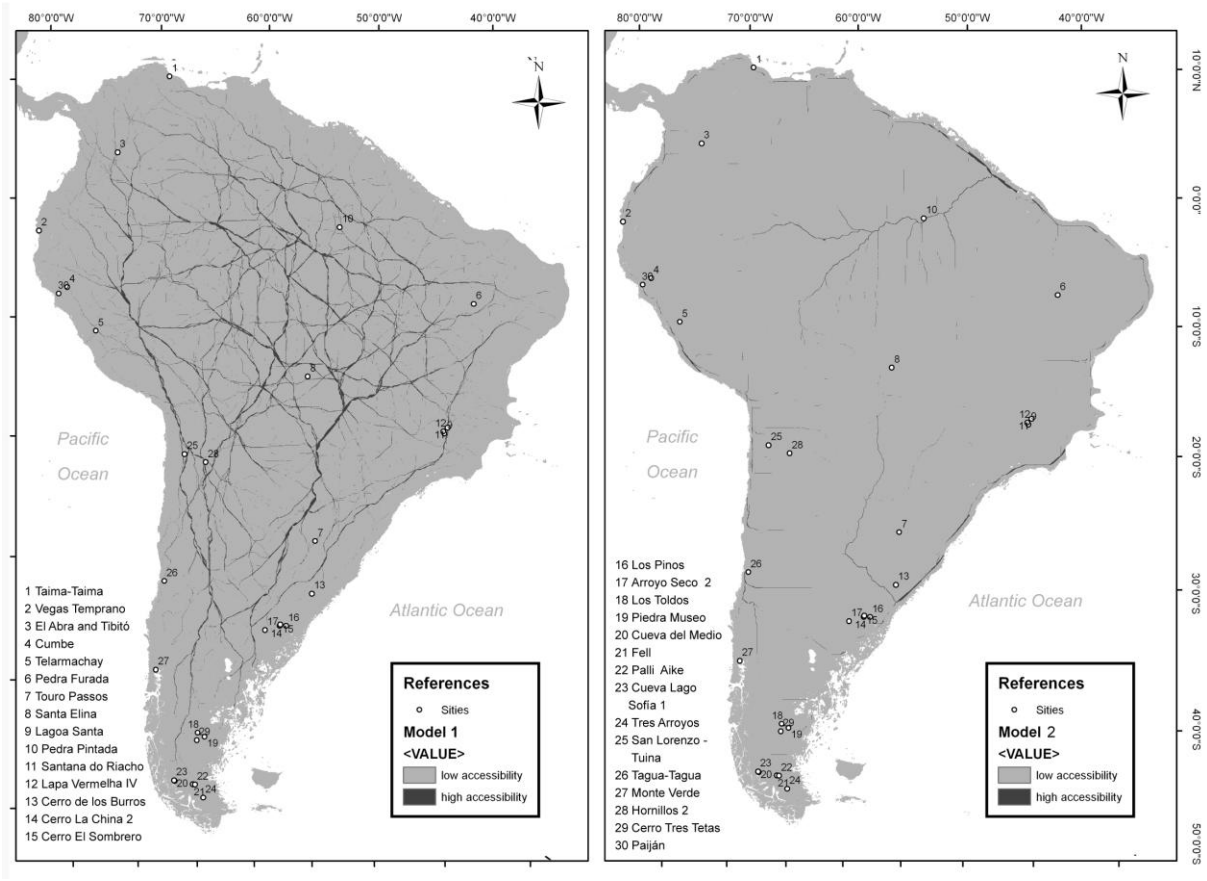
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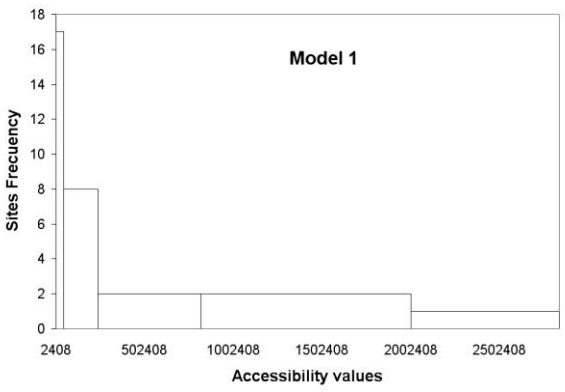
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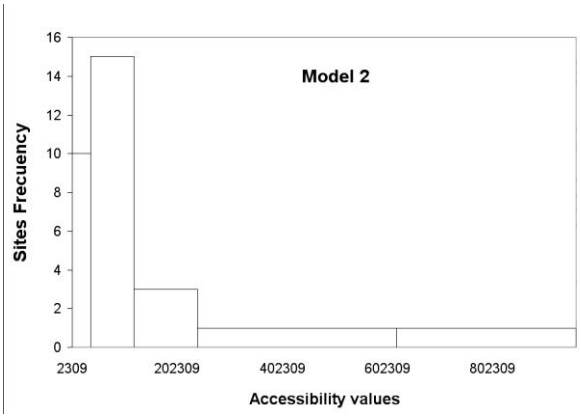
**Figure captions**

Figure 1. Archaeological sites located on model 1 and 2. Accessibility values are symbolized in two classes (low and high) by the method of natural breaks.

Figure 2. Sites frequencies in five bins defined by natural brakes in the accessibility values for model 1 and model 2. In model 1 seventeen sites fall in bin 1 (see figure 1 to identify the following sites numbers: 3, 4, 7-12, 14-16, 19, 22, 24-25, 27-28); eight sites fall in bin 2 (1, 5-6, 13, 17, 23, 29-30); two sites fall in bin 3 (2, 26); bin 4 (18, 20); and one site in bin 5 (21). In model 2 ten sites fall in bin 1 (1, 4, 8, 11, 14-15, 19, 26, 29-30); fifteen sites in bin 2 (3, 5, 6-7, 9, 10, 12, 13, 16-18, 22-23, 25, 28); three sites in bin 3 (2, 21, 27); one in bin 4 (24); and one in bin 5 (20).


80°0'0"W
70°0'0"W
60°0'0"W
50°0'0"W
40°0'0"W
10°0'0"N
0°0'0"
10°0'0"S
20°0'0"S
30°0'0"S
40°0'0"S
50°0'0"S
N
Pacific Ocean
Atlantic Ocean
1 Taima-Taima
2 Vegas Temprano
3 El Abra and Tibitó
4 Cumbe
5 Telarmachay
6 Pedra Furada
7 Touro Passos
8 Santa Elina
9 Lagoa Santa
10 Pedra Pintada
11 Santana do Riacho
12 Lapa Vermelha IV
13 Cerro de los Burros
14 Cerro La China 2
15 Cerro El Sombrero
References
Sities
Model 1
<VALUE>
low accessibility
high accessibility
16 Los Pinos
17 Arroyo Seco 2
18 Los Toldos
19 Piedra Museo
20 Cueva del Medio
21 Fell
22 Palli Aike
23 Cueva Lago Sofía 1
24 Tres Arroyos
25 San Lorenzo - Tuina
26 Tagua-Tagua
27 Monte Verde
28 Hornillos 2
29 Cerro Tres Tetas
30 Paiján
Model 2


Model 1
Sites Frecuency
Accessibility values
2408
502408
1002408
1502408
2002408
2502408


Model 2
Sites Frecuency
Accessibility values
2309
202309
402309
602309
802309