South America 18,000 Years Ago: Topographic Accessibility and Human Spread 1

Laura Miotti[1] *and Lucía Magnin*[1] 2

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Theorized entrance routes to the South American continent have been debated throughout the twentieth century (i.e., Martin 1973; Sauer 1944), and they are still being discussed and contested. Among the factors analyzed in the diverse theories are demographic considerations, paleoenvironmental conditions, the effect of natural barriers, the availability of resources necessary for survival, and various technologies used by the first colonizers. Most prevailing theories propose that populations either followed a strategy of terrestrial advance or moved along rivers and coastlines. 4

The models for settlement of early America therefore propose two fundamentally different lifeways for these highly mobile groups, terrestrially adapted (Martin 1973) and water adapted (Bryan 1978; Dixon 2000; Erlandson 2001; Fladmark 1983; Meltzer 1993). In the first case, human movements adhered to a terrestrial-advance strategy; in the second case, population movements followed rivers and coastlines (Miotti 2006). 5

Methodologically, models predicting possible routes have applied several lines of evidence, such as human craniometrics and genetic analysis (Meltzer 1993; O'Rourke and Raff 2010; Pucciarelli et al. 2006), demographic simulations (Gillam et al. 2007; Steele et al. 1998), and digital modeling of territorial analysis (Anderson and Gillam 2000). 6

This paper proposes a geographic digital-modeling approach, such as that suggested by Anderson and Gillam (2000). Our main goal is to contrast two digital models of terrain

[1] CONICET – División Arqueología del Museo de la Plata. Arqueología de Paisajes Patagónicos (FCNyM – UNLP), Paseo del Bosque s/n, CP: 1900, L Plata, Buenos Aires, Argentina; e-mails: laura.miotti2@gmail.com lmagnin@fcnym.unlp.edu.ar

accessibility generated for South America presented by Magnin et al. (this volume), against
7 archaeological data for the earliest occupations on the continent. The models contrast the two prevailing ideas concerning human dispersal across the continent (terrestrial vs. littoral and riverside). We assess both models and discuss objections to both.

It is reasonable to assume that during the colonizing process, areas with lower costs of access to humans were settled before areas naturally less accessible (Borrero 1995; Miotti 1998, 2006). Therefore people moving through the landscape would have chosen more-accessible
8 paths, for example, flatlands, coastal plains, and river banks, rather than strenuous routes, such as mountainous terrain. We can also assume that glacial masses were barriers to general movement. After analyzing the data, we will discuss whether one of the models better fits the data, evaluate the predictive potential of both models, and finally propose alternative models for human dispersal across the continent.

9 Data, Method, and Results

The data include two digital models (Figure 1) and a set of geo-referenced archaeological information. The digital models are raster maps whose individual cells contain accessibility values presented in Magnin et al. (this volume). They were generated based on (1) estimated
10 bathymetry for the span ca. 18,000–9000 RCYBP, (2) inland altitudinal values (masl), and (3) glacial extent (Magnin et al. 2010, this volume). Archaeological data include 30 sites with reliable contexts dated to earlier than 10,500 RCYBP, when glacial withdrawals and re-advances took place (Rabassa 2008) (Figure 1).

The applied methodology assigns an accessibility value from each model to every site, by means of value extraction using Zonal Statistics in GIS Spatial Analyst (http://webhelp.esri.com/arcgisdesktop/9.2.), to obtain a value distribution for each model. The value obtained is not the localized
11 pixel value of the precise location, but a median value calculated for a 10-km buffer surrounding the site. This method determines the accessibility of the territory immediately surrounding each site and avoids possible errors caused by assigning values 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.

12 Discussion

According to the expected pattern (sites should be located in areas with highest accessibility values) the results indicate that the data fit model 2 better than model 1. Since we can assume that most of the coastal evidence from the earliest period is submerged today, inferences about population movements along the coast cannot be verified. The analyzed evidence could be
13 valid, however, for showing that riversides were traveled intensely since the earliest times. These results, however, must be considered a first step in developing and testing models. Although we could detect trends in the data, we could not rule out or confirm any of the theoretical models discussed. Furthermore, the models may not be mutually exclusive (Miotti 2006).

We conclude that a GIS-based dispersal model is a thought-provoking way of analyzing archaeological data relating to early human occupations. It describes complex patterns of
14 mobility as a digital map which can be analyzed to detect spatial trends in archaeological data. Future work and testing could lead to a better fit between the archaeological data and models.

Furthermore, the present study has launched an intense discussion of the South American data. Although definite patterns of site accessibility have emerged and model 2 had a higher

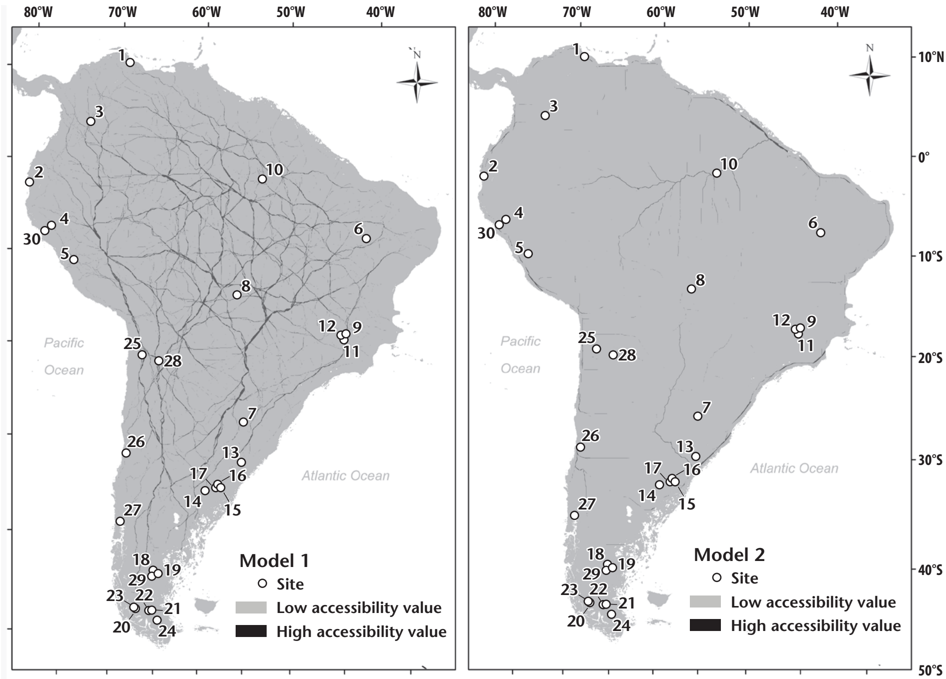

Figure 1. Archaeological sites located on model 1 and model 2 dispersal maps (generated by Magnin et al. (this volume). Accessibility values are symbolized in two classes (low and high) by the method of natural breaks. Sites:

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
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 Sofia 1
24 Tres Arroyos 22
25 San Lorenzo-Tuina
26 Tagua-Tagua
27 Monte Verde
28 Hornillos 2
29 Cerro Tres Tetas
30 Paiján

predictive value, it would not be right to assume that the location of early sites can be explained 15
solely in terms of environmental variables (Kohler and Parker 1986). Instead, human choices may have been differently motivated.

Conclusions 16

In this paper we sought to find patterns of differential mobility and use of specific environments as a way to characterize the strategies employed by dispersing first Americans. The results favored model 2, the model representing water-adaptation strategies, as the model
that better fits the analyzed data. The current discussion dealing with theories and methods, 17
however, shows that in light of the great potentiality of the methods and the complexity of the issue, neither the terrestrial nor the water-based model can be rejected at the moment.

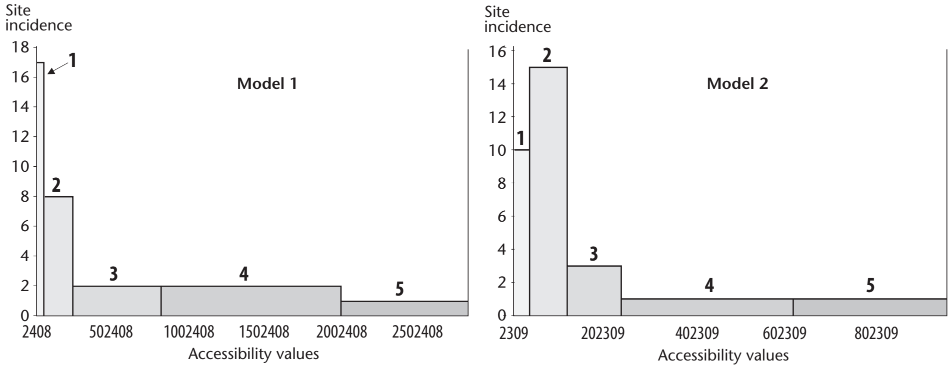

Figure 2. The quantity of sites registered in each of five bins defined by natural breaks in the accessibility values for model 1 and model 2. The following table lists the specific sites contained in each accessibility-value bin (see Figure 1 for site numbers).

Model 1

bin 1: site no. 3, 4, 7–12, 14–16, 19, 22, 24–25, 27–28
23 bin 2: site no. 1, 5–6, 13, 17, 23, 29–30
bin 3: site no. 2, 26
bin 4: site no. 18, 20
bin 5: site no. 21

Model 2

bin 1: site no. 1, 4, 8, 11, 14–15, 19, 26, 29–30
bin 2: site no. 3, 5, 6–7, 9, 10, 12, 13, 16–18, 22–23, 25, 28
bin 3: site no. 2, 21, 27
bin 4: site no. 24
bin 5: site no. 20

18 Future studies could incorporate more archaeological and environmental data with more accurate dating to analyze which areas were repetitively occupied, to evaluate possible changes adopted through time, and to add more information about how spatial knowledge of territories was built into the long-term process of the peopling of the South American continent.

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