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C H A P T E R   T E N

Linguistic Diversity Zones and Cartographic Modeling: GIS as a Method for Understanding the Prehistory of Lowland South America

Östen Dahl, J. Christopher Gillam, David G. Anderson, José Iriarte, and Silvia M. Copé

The vast geographic scale, time depth, linguistic variability, and inherent complexity of long-term cultural trajectories influencing social ethnogenesis in lowland South America have presented scholars with many challenges in the past century (see Hornborg and Hill, this volume). However, it is this multifaceted character of the problem that lends itself to meaningful interpretations of ethnic identity and transformation in Amazonia. Traditional methods that focus on specific localities or groups and then extrapolate to the broader area often create generalization where differentiation is due. With few exceptions, our ability as anthropologists to manage and manipulate vast quantities of cultural and environmental data has lagged behind the technological advances of recent decades. Nonetheless, progress is being made on the technological side as user-friendly applications become more mainstream in the academic setting.

Advancements in the design and implementation of archaeological databases, geographic information systems (GIS), and cartographic modeling enable archaeologists today to construct empirical models of past cultural systems at a variety of scales. GIS environmental and archaeological datasets for lowland South America have recently become available at various resolutions that can be used to address a broad range of questions. Examples of significant environmental GIS data include 1 km resolution datasets such as GLOBE and HYDRO1K for regional-scale analyses and high-resolution 90 m data such as SRTM digital elevation model (DEM) data suitable for local-scale studies. Archaeological datasets remain project specific (e.g., Copé 2007), with few region-wide databases currently available. This situation may become less restrictive in the years ahead as accessible, and ideally online, projects such as the Paleoindian Database of the Americas (PIDBA) and others make regional- and continental-scale datasets available to archaeologists worldwide (Anderson et al. 2005, 2010; Gillam et al. 2008; Suárez and Gillam 2008).

The challenge for current research in Amazonia is to expand the use of GIS beyond data storage and visualization. Pioneering geographic studies will lead to a better understanding of the unique historical trajectories that shaped the landscape over time. Research directed toward defining group association and territories, as well as routes and networks for migration, interaction, and trade between human groups, will permit the development of a better understanding of cultural landscape change, human agency, and the uniqueness of specific cultural trajectories. For example, Thiessen polygons (Haggett 1966) are a simple method of evaluating potential territory size and, when combined with other cartographic modeling output (e.g., predictive models), provide an effective estimation of territorial extent and potential productivity. Kinship, natural resources, and polity strength also shape (and reshape) such boundaries over time and need to be integral to the modeling process whenever possible. Least-cost paths analyses provide the means to examine overland movements on the landscape and, when expressed in units of caloric cost, represent an economic variable for understanding trade and interaction.

In this chapter, we explore current uses of cartographic modeling techniques in archaeology and suggest how some of these techniques—especially GIS and least-cost paths analysis—may contribute new understandings of long-term processes of ethnogenesis and historical change in ancient Amazonia. We will conclude with a brief consideration of the interesting discovery that the results of least-cost pathway modeling of early movements into the interior of South America bear striking resemblance to the contemporary geographic distribution of language isolates and members of very small language families in western areas of Amazonia. This finding suggests a scenario in which ancestral languages might have arrived at the time of the earliest human migrations into South America and given rise to daughter languages whose speakers have continued to inhabit the same regions of western Amazonia.

LEAST-COST PATHS AND CALORIC COST

Least-cost paths analysis provides an empirical and replicable means of modeling terrestrial routes or movement corridors across a landscape using a DEM and site location data. Typically, the elevation values of the DEM are converted to percentage slope, degree of slope, or caloric cost to represent a roughness layer for the model. Percentage and degree of slope are calculated from the DEM grid layer using a moving 3×3 neighborhood of cells (each center cell and its 8 adjacent neighbors) and is equivalent to calculating the local derivative of a plane. Values for percentage slope range from 0 to infinity (not 0 to 100) as steepness increases. Values for degree of slope only range from 0 to 90 degrees as steepness increases. Either method can be used for deriving least-cost paths; obviously, there will be a greater range of values influencing the results with percentage of slope than for degree of slope.

For caloric cost, Pandolf, Givoni, and Goldman (1977) provide an equation for estimating energy expenditure for people moving at walking speeds. The unit of measure of that equation is in watts, easily converted to nutritional calories by multiplying the equation by 0.000238846. The modified equation (Gillam 2008) is:

$$\text{Nutritional Caloric Cost} = (((1.5 * W) + (2 * (W + L) * ((L / W) * (L / W))) + (T * (W + L) * ((1.5 * (V * V)) + (0.35 * V * \%SLOPE)))) * 0.000238846)$$

In the GIS, the percentage slope grid layer is used as the mapped variable in the equation to derive nutritional caloric cost for each cell on the landscape. The additional variables include a hypothetical subject weight (W; kilograms), carrying load (L; kilograms), terrain factor (T; value range from 1.0 to 2.0: 1.0 for hard surface, 2.0 for loose sand), and hypothetical walking speed (V; m/s).

The least-cost paths are derived by a "wave" function acting on the roughness layer (Tomlin 1990). From the starting cell (such as an obsidian quarry site), a wave front extends in all directions and is impeded by the values of the roughness layer (the percent slope or caloric cost values in the adjacent cells). For each cell, a cumulative cost of movement is established from the source. A least-cost path is then created by defining a destination cell (archaeological site or sites) from which the minimum cumulative cost is traced backward through the cost surface to the source cell.

Anderson and Gillam (2000) used this method to explore potential migration corridors for the peopling of the Americas during the late Pleistocene. Likewise, Gillam and Tabarev (2004) examined possible exchange networks of obsidian raw materials in Primorye by linking known quarry locations with habitation sites throughout the region. If caloric cost is used instead of slope, the cumulative cost between the source and destinations can be further used as an economic variable to evaluate hypotheses related to interaction and exchange practices in a region.

PROSPECTS FOR GIS MODELING IN AMAZONIA

The complex cultural trajectories of prehistoric Amazonia are becoming well understood, and research interest in the human ecology, sociopolitical organization, settlement systems, and migration, interaction, and exchange networks of the region remains fervent (Neves 1998; Heckenberger, Peterson, and Neves 1999; Hornborg 2005; Erickson 2008; Roosevelt 2008). The use of GIS modeling in Amazonia can go far beyond mapping of site distributions and can provide new insights into the complex cultural dynamics of the region through time and space. There are a variety of free online global-scale GIS data sources in the United States and elsewhere that are enabling cartographic modeling in Amazonia and other regions of South America for the first time. Of particular interest are the Shuttle Radar Topography Mission (SRTM) 90 m DEM; the GLOBE, HYDRO1K, and GTOPO30 1 km resolution DEM datasets; and the ETOPO2 4 km resolution DEM data that also include seafloor bathymetry for modeling palaeo-landforms and shorelines (e.g., Gillam et al. 2006).

In Rio Grande do Sul, Brazil, recent research in the southern Brazilian highlands highlights the significance of regional data sources, such as national base-map datasets, for conducting archaeological GIS analyses. DEMs and derivative GIS data were developed from Brazilian 1:50,000-scale elevation contour maps to study the cultural landscapes of the Taquara tradition near Pinhal da Serra and Bom Jesús (Copé 2007). The sites at these localities are characterized by pithouse habitations and mounded funeral enclosure complexes. At Bom Jesús, nearest neighbor analyses and Thiessen polygons revealed that Taquara sites (n = 53) were significantly clustered, not randomly located, on the landscape. GIS three-dimensional visualization of the sites also revealed that they were intentionally positioned on the landscape to maximize viewshed. Likewise, GIS analyses of 104 Taquara sites in the Pinhal da Serra locality revealed that pithouses were often located along least-cost pathways on the landscape. Interestingly, funeral mound enclosure complexes seem to be located at nodal points connecting least-cost paths across the landscape, and these funerary sites are all intervisible to one another. These patterns suggest non-random distributions of habitation sites and symbolic meaning in the placement of funerary sites.

The SRTM 90 m DEM data form the highest-resolution global dataset freely available today and will result in a significant expansion of GIS applications in archaeology throughout the world, particularly in rural areas such as Amazonia. In the southern Brazilian highlands, SRTM data are being used to explore the expansion of Taquara/Itarare culture in Misiones Province, Argentina, where mounded earthen funeral enclosures also served as significant ceremonial places and territorial markers on the landscape (Iriarte, Gillam, and Marozzi 2008). The DEM was used to develop ancillary datasets (e.g., slope model and stream networks) that were in turn utilized as variables in a predictive model of site location for the Piray mini basin. The predictive model serves as the basis for a stratified random sampling strategy for gaining a better understanding of Taquara/Itarare settlement and sociopolitics of the river basin that lies on the periphery of the greater culture area.

AN AMAZONIAN CASE STUDY: LINGUISTIC DIVERSITY ZONES AND POSSIBLE INITIAL IMMIGRATION PATHWAYS IN SOUTH AMERICA

For a long time, the Americas, in particular South America, have been reputed to house an unusually large number of unrelated language families. In spite of Joseph Greenberg's late twentieth-century attempt to subsume all languages in the Americas under three families, one of which, "Amerind," would cover all languages traditionally regarded as "American Indian" except those belonging to the Na-Dene family in North America, most linguists still regard the Americas as having a higher degree of linguistic diversity than other continents. Usually, statements to this effect are formulated in a rather general fashion and are often restricted to noting the large number of language families in the Americas, in particular in South America. Digital databases and mapping techniques (GIS) now make it much easier to study the distribution of both genealogical (genetic) and structural diversity and relating them to each other. In this section, we shall focus on South America, presenting a bird's-eye view of the linguistic diversity found there, and try to relate it to recent proposals about the initial peopling of the continent.

For genealogical (genetic) diversity, we will be using the Ethnologue database (Gordon 2005), not because it is more authoritative than any other work but because it not only has reasonably full coverage of South America but also presents data on other parts of the world, making global statistical comparisons possible. Although the Ethnologue differs in details from other surveys, those details are of little importance to the general picture, which is more or less the same in most recent sources.

The number of living spoken languages of pre-Columbian origin in South America is around 400; according to the Ethnologue database there are 381 such languages, which is about 5.5 percent of all living languages in the world. A considerable number of languages are also known to have gone extinct; the Ethnologue lists over 100 but there are many more not mentioned there. For many of the languages, in particular the extinct ones, there is not sufficient available information to determine their genealogical (genetic) relationships; the Ethnologue lists thirty-three such languages in South America, eleven of which are said to be still spoken. This leaves us with 370 languages that are given a genealogical classification in the Ethnologue. Most of them are assigned to one of thirty-four language families, which make up one third of the total number of language families listed in the Ethnologue; this figure in itself shows us that the diversity in South America

MAP 10.1. *The distribution of language isolates and small language families (fewer than four members) in the world.*

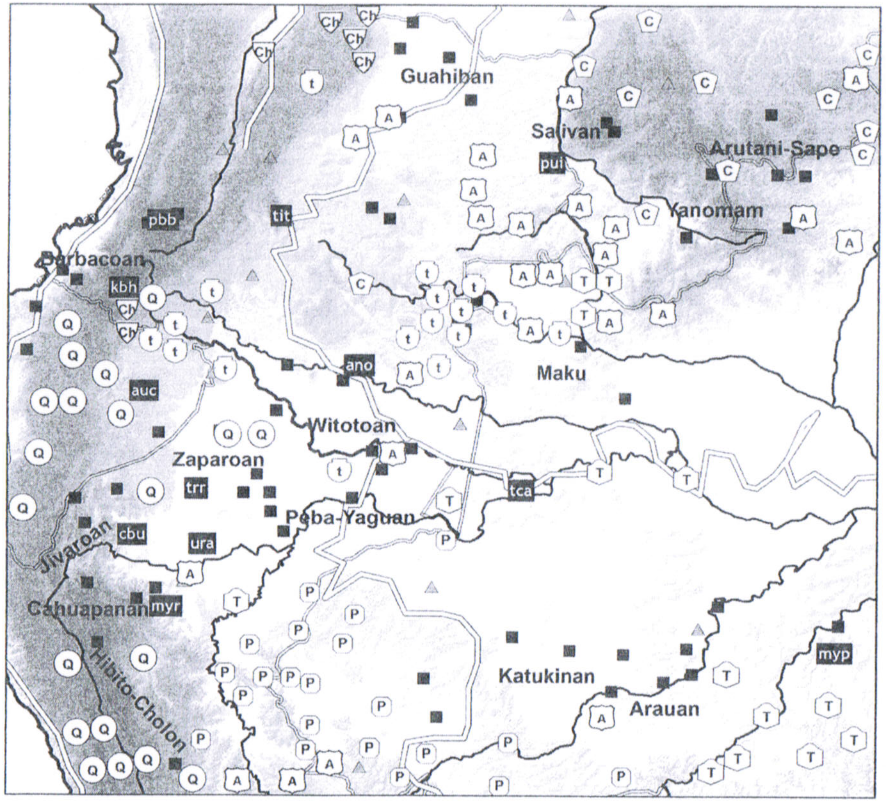
is higher than in the rest of the world. Twenty languages, however, are classified as "language isolates," meaning that there is supposedly sufficient information about them to determine that they do not belong to any known language family.[1] The total number of living isolates in the world according to the Ethnologue is thirty-six,[2] so here the South American cases make up as much as 60 percent. Map 10.1 shows the distribution of language isolates and language families with fewer than four members in the world. It is obvious that the clusterings in the western parts of South America have no counterparts anywhere else.

If we look closer at the genealogical and geographical distributions of the indigenous languages in South America, we can see that they are far from even. There are nine families with more than ten members. These are Tupí (57), Arawakan (47), Quechuan (44), Carib (28), Macro-Gê (24), Tukanoan (20), Panoan (19), Chibchan (11), and Mataco-Guaicuru (11). Together they have 259 members, which is 70 percent of the classified languages in South America. At the other extreme, sixty languages are isolates or belong to families with fewer than four members. Map 10.2 shows that the latter group are not spread evenly over the continent but are concentrated in the western half—in fact, there is not a single such language east of 57°W. The majority are located in two relatively restricted regions, shown on Maps 10.3–10.4. The larger one, what we will call the "northern diversity zone," is centered in northern Peru, along the Marañon River at the foothills of the Andes, but spills over into Ecuador, Brazil, Colombia, and Venezuela. The second, the "southern diversity zone," covers northern Bolivia and surrounding areas of Peru and Brazil. These regions, then, have the highest linguistic diversity in the world from the genealogical point of view, if we are to believe standard assumptions about genealogical affiliations of languages.

MAP 10.2. *The distribution of language isolates and small language families (fewer than four members) and the "least-cost pathways" of Anderson and Gillam (2000).*

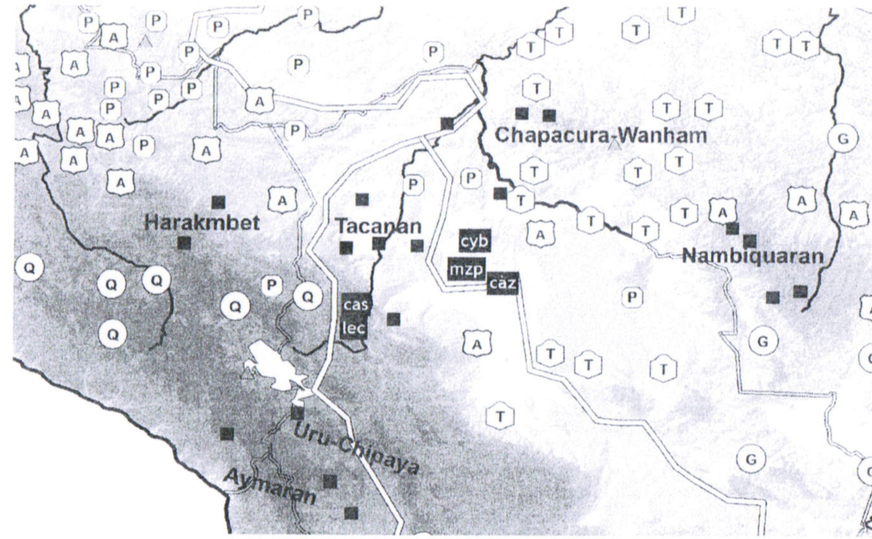
The last caveat is important, because it is of course possible that these assumptions are wrong. It could well be that future research will show that, in fact, many of the small families and isolates are related. Before discussing this question, we should first look at another kind of diversity, that is, typological or structural diversity.

The genealogical diversity of South America is matched by diversity also with respect to the structural properties of languages (Dahl 2008). This conclusion is based on the data presented in the World Atlas of Language Structures, WALS (Haspelmath et al. 2005), a typological atlas mapping the geographical distribution of about 140 linguistic features. On the basis of the database underlying WALS, a measure of typological distance was defined between languages in terms of the proportion (expressed as a percentage) of structural features with respect to which they differed (Dahl 2008). For instance, the difference between English and French was 24.0 and that between English and Imbabura Quechua, 46.3. Each map in WALS shows a sample of the world's languages, which varies from map to map; because



MAP 10.3. *The northern diversity area. Black symbols represent languages belonging to families with fewer than ten members; languages belonging to larger families are shown as encircled letters (A = Arawak, C = Carib, T = Tupí, Q = Quechua, P = Pano, t = Tukano, Ch = Chibcha). Three-letter abbreviations represent language isolates; gray circles, unclassified languages. For explanations of abbreviations for languages and language families, see the Ethnologue Language Code Index (www.ethnologue.com /language_code_index.asp).*

of this, the study focused on the set of 222 languages that were represented on the largest number of maps. One way (not unproblematic) of measuring the internal typological diversity of an area is by the average distance between the languages from that area in such a sample. The average distance between pairs of languages in the whole 222 sample is 41.73. Continents such as Europe and Africa, with 23 and 38 languages in the sample, have average typological distances of 34.2 and 37.2, respectively. The average distances in Europe and Africa are thus considerably lower than the world average; not unexpectedly, the languages in these continents are more similar to each other than languages chosen arbitrarily from the world's



MAP 10.4. *The southern diversity area. For explanations, see Map 10.3.*

languages. This is due to both genealogical affinities and areal pressure, that is, structural convergence due to contact between geographically close languages. The average distance between the twenty-eight pre-Columbian South American languages, however, is 41.1, not significantly lower than the world average, suggesting that the internal typological diversity of the continent is quite high. We should treat these figures with some caution, perhaps, since they depend on, among other things, how well the languages have been sampled. A few other measures have been quoted, some of which suggest that South America and Africa have roughly the same internal diversity (Dahl 2008); even this is rather striking in view of the fact that Africa has five times as many languages as South America. But what may be more relevant to our discussion is what happens if we (somewhat like Pope Alexander VI) divide South America into two halves and measure the internal diversity in those. Dividing the twenty-eight South American languages along the 65th west parallel yields average typological distances of 39.0 (to the west) and 41.6 (to the east). In other words, even these smaller areas still appear to have a higher internal diversity than the whole of Africa.

Another way of illustrating the structural diversity of South American languages is to look at some individual typological parameters. An important such parameter is what (following Greenberg 1963) is often called the "basic word order" (BWO) of a language, loosely defined as the typical order of subject, verb, and object in a declarative main clause. Which BWO a language has is largely predictable from where it is spoken: thus, most of the Asian continent belongs to a zone with almost exclusive SOV (subject-object-verb) order, except Southeast Asia, which is equally solidly SVO (subject-verb-object) and a few VSO languages at the western end of the continent. By contrast, in a rectangular area of about 1 million square kilometers just south of the equator in western Amazonia, and largely coinciding with the northern diversity zone, all six logically possible basic word orders are found (including the rare ones where the object precedes the subject) and, in addition, languages "with no dominant word order" (Dryer 2005).

What all this suggests is that although there are no doubt structural features that tend to unite South American languages (such as the ones discussed for Amazonia in Aikhenvald and Dixon 1999:8–9), areal pressure has been lower than in many other parts of the world. There is also little evidence from structural similarities to indicate that there are hitherto undiscovered large-scale genealogical relationships within the time span where such relationships have not yet been obliterated by language change.

Nichols (1990:475) claimed that the linguistic diversity found in the New World is so great that it can only be explained if the New World was colonized much earlier than is usually assumed, "perhaps some 35,000 years" ago. Nettle (1999:3325) argues against the assumption that genealogical diversity increases over time. Rather, he says, it is the other way around: "[E]arly in the peopling of continents, there are many unfilled niches for communities to live in, and so fissioning into new lineages is frequent. As the habitat is filled up, the rate of fissioning declines and lineage extinction becomes the dominant evolutionary force." Aikhenvald and Dixon (1999:16) argue for a "punctuated equilibrium model" of language development (also discussed in Dixon 1997), according to which periods of equilibrium, during which languages in an area tend to become more similar structurally, converging toward a common prototype, are punctuated by "cataclysmic events" during which peoples and languages expand and split. Applying this model to South America, they assume that after the initial entry about 12,000 years ago, people "would quickly have expanded to fill the continent . . . There would have been many small groups of hunters and gatherers living in a state of relative equilibrium with each other. Linguistic traits would have diffused across the languages in each region." Then, about 5,000 years ago, the adoption of agriculture triggered a major punctuation, leading to the expansion of families such as Arawak, Carib, and Tupí, although leaving scattered groups of hunters and gatherers between the settlements of agriculturalists.

Nettle and also Aikhenvald and Dixon seem to think of an increase in diversity as essentially being limited to periods during which there is movement of people. But it does seem more correct to think of these periods as the initial points of longer periods of gradual divergence. If a language community splits up into two groups, the languages used by the two groups will accumulate changes that will make them more and more different from each other; this will only partially be mitigated by

convergence that is due to subsequent contact between the groups, and the extent of this convergence will depend on the degree of contact. A net gain in structural similarity is not plausible unless two initially very dissimilar languages get into close contact with each other. In the case of western Amazonia, it appears that the degree of contact has on the whole been relatively low, which has allowed the typological distances between the languages to grow over time.

Nichols is most probably correct in assuming that it takes a very long time for two languages to diverge so much that their genealogical relationship will not be recognizable. Thus, assuming no recent immigration of any significance, a high degree of diversity in an area does indicate that the initial settlement took place at a relatively remote point in time. However, at the same time there are always forces present that counteract the increase in diversity, not only convergence through language contact but also extinction of lineages through language shift and population replacements, as Nettle notes. What we can see in South America, then, is that over large areas, any previously existing diversity was wiped out when the agricultural expansion took place. In addition, European colonization has led to the extinction of indigenous languages over large stretches in central Amazonia. The areas of high diversity, however, appear to have been spared these processes to a large extent. It is reasonable to assume that the isolates and members of small families in these areas have been there at least since the expansion of the large families, but what things looked like before that is of course not immediately obvious. Theoretically, the languages in question could be the remnants of earlier expansions within the continent, or they could derive from the initial peopling of the Americas.

As noted above, we can see from Map 10.1 that small lineages are rather seldom clustered together. Except for the Amazonian diversity areas, the only place where we can see more than two such lineages close together is western New Guinea, but even there the clustering is considerably smaller. Thus, in many places, language isolates or small families look more like accidental survivors of the expansion of larger families, or they are situated in locations of very low population density, such as northern Siberia. The concentration in western Amazonia, on the other hand, in particular that along the Marañon River, calls for an explanation of another kind.

Anderson and Gillam (2000:46) calculate "least-cost pathways between presumed points of initial human entry into North and South America and 45 early archaeological sites selected to provide coverage to most parts of each continent." For South America, the most striking result is that

> the primary pathway does not follow the coastline for more than a short distance but instead swings south near Caracas . . . and proceeds through the central part of the continent well to the east of the Andean chain . . . While movement in the interior of South America may seem implausible, it must be remembered that in the Late Pleistocene some of this region may have been in grassland, scrub forest, or savannahs. (Anderson and Gillam 2000:51)

What is striking is that a large part of the language isolates and members of small families are located quite close to these possible routes for the initial entry of humans into South America, suggesting a possible scenario where those languages (or rather their ancestors) would have arrived with the first peopling of the continent and then remained in place until the present day.

Even if some of the assumed isolates and small families in South America turn out to be genealogically related to each other or to other languages, it is unlikely that the present-day linguistic diversity of western Amazonia has arisen through splits that have taken place after the estimated time for the expansion of the large families; this would most probably have left more easily observable traces in the form of common vocabulary and structural similarities. It is also unlikely that the diversity has arisen through migration to the diversity areas after that date, given that the diversity areas are more or less encircled by the large families. One possibility is of course that it was the expansion of those families that pushed some or all of the small groups into the diversity zones. At present, the northern diversity zone, which is the largest one, makes up some of the remotest and most inaccessible parts of South America,[3] so it would appear plausible that they would be colonized last. However, Anderson and Gillam's suggestion that the situation looked quite different at the time when the continent was first populated opens up another possibility: that these regions were in fact among the earliest to be reached, but that the groups who settled there were later more or less trapped when the climate and the vegetation changed. Until we know more, such a suggestion will have to remain speculative, but given that the linguistic diversity found in western Amazonia is unique, it may also need a rather complex story to explain it.

NOTES

1. The distinction between "unclassified languages" and "language isolates" is a tricky one. Not only is it problematic to determine when there is enough information to rule out a genealogical relationship between a language and established language families, but the existence of unclassified languages, where information by definition is insufficient, also makes it impossible to exclude that an assumed language isolate in fact has relatives among hitherto unclassified languages. Also, as is discussed in the main text, relationships that are older than the time limit for the application of traditional historical-comparative methods cannot be taken into account.

2. Some of the speaker information in the Ethnologue is rather old, so this estimate is probably too high. However, there are some isolates that are not mentioned at all in the version of the Ethnologue used, such as Aikaná and Kwazá. It should also be noted that the estimates given in the Ethnologue are by no means higher than those found in other sources. Thus, according to the Multitree website (multitree.linguist.org), Campbell and Grondona (forthcoming) postulate sixty-two isolates in South America, out of which twenty-eight are still spoken.

3. The southern diversity zone is different in this regard, since the largest concentration of isolates and small families is not in a particularly inaccessible place; in fact, it is within or close to the savanna-like area called Llanos de Moxos, where in pre-Columbian times there was an advanced system of "raised-fields" agriculture. It is rather unexpected for radical linguistic diversity to be compatible with an economy of that kind, but it is possible that the diversity of this particular region is indeed a result of later migrations.

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C H A P T E R   E L E V E N

Nested Identities in the Southern Guyana-Surinam Corner

Eithne B. Carlin

INTRODUCTION

This chapter explores the history of contact between several borderland language communities who live in the triangle that forms the southern border between Guyana and Surinam. In particular, focus is on the histories of four groups in this triangle that have been intricately intertwined through trade and intermarriage for more than two centuries, namely the Waiwai, Mawayana, Taruma, and Wapishana. Linguistically these four groups are quite distinct in that Waiwai belongs to the Cariban family, Mawayana and Wapishana are Arawakan languages that share no more than half of their basic vocabulary, and Taruma is unclassified. An additional group that held some dominance, though short-lived, on the Essequibo in the eighteenth century was the Manáos, who spoke an Arawakan language.

Although the larger and dominant groups on the Guyanese side of the border nowadays are the Wapishana and Waiwai, many Guyanese toponyms and hydronyms in the Rupununi are of Taruma origin, an indicator of Taruma dominance at some stage in history.

Ethnicity

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