ARTICLE 4: LAGUNA DE ARENAL SHORELINE SURVEY

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ABSTRACT

A survey of the Laguna de Arenal shoreline in northwestern Costa Rica was conducted during March and April of the 1984 Proyecto Prehistórico Arenal field season. A total of 22 were located, which range chronologically from early Period IV Tronadora Phase (1000 - 500 B.C.) to late Period VI Tilarán Phase (100 - 1500 A.D.). Occupation appears to have been greatest during late Period IV Arenal Phase (500 B.C. - A.D. 500). Environmental viariability and regional stratigraphic sequences are related to settlement patterns.

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INTRODUCTION

The focus of Proyecto Prehistórico Arenal is the reconstruction of prehistoric subsistence strategies and settlement patterns in a volcanically active area, within the theoretical framework of human ecology. Thus, a major emphasis of the survey was the location of habitation sites and other activity areas. The shoreline survey offered unique opportunities. The shoreline crosscuts a number of different ecological zones, allowing us to examine multiple environmental variables in relationship to settlement patterns and potential resources. Erosion of the shoreline provided the advantage of exposure of sites in deeper stratigraphic levels; such sites would otherwise have been difficult to detect because they are generally buried by 1 to 3 meters of tephra deposits and soils. Another major objective of the survey was to further define the regional stratigraphic sequence (see Appendix A, Article 3). Knowledge of the regional stratigraphic sequence should facilitate understanding of the relationships between sites, settlement patterns and environmental variables in a chronological context.

THE SURVEY AREA

The Cuenca de Arenal is a tectonic depression between the Cordillera de Guanacaste and the Cordillera de Tilarán in northwestern Costa Rica. Today the cuenca is occupied by the Laguna de Arenal, a large northwest-southeast trending lake, whose waters at the time of the survey were at an elevation of 540 meters above sea level. The current lake level is the result of the construction of the Sangregado earthfill dam and filling of the lake for the Arenal Hydroelectric Project. The lake level before the construction and filling was 512 meters; however, there is evidence of considerable fluctuations in the lake level in the past, ranging from 480 to 530 meters in elevation (Tosi 1980). Unfortunately, at present there is little information available as to the take level at any given time.

Volcán Arenal and Cerro Chato, at the eastern end of the lake, dramatically dominate the region, both visually and geologically. Volcán Arenal is an almost perfectly conical stratovolcano, rising to an elevation of 1633 meters, with a roughly circular base 4 kilometers in diameter. Cerro Chato southeast of Arenal is the collapsed caldera of an older volcano. These volcanoes are probably the youngest members of a regional volcanic cordillera running from Volcán Orosi in the northwest to Volcán Irazú in the southeast.

Volcán Arenal continues active today following its last violent eruptive phase in 1968 (Melson, in press), and must certainly have played an important role in prehistoric adaptations in the survey area. Nine previous prehistoric eruptions are known, and the beginning of Arenal's activity may date to 3000 B.C. (Melson, in press). The regional stratigraphic sequence is derived from tephra deposits from eruptions of Arenal and possibly Cerro Chato as well (Article 3).

Underlying these more recent volcanic strata is the Aguacate Formation which consists of a thick series of agglomerates, andesite and basalt lava flows, breccias, and tuffs of the Miocene to Pliocene eras (Castillo-Muñoz 1983). This formation is readily recognizable in the field as an orange-to-red weathered formation of extraordinarily high clay content. The overlying more recent volcanic deposits at the western end of the lake may measure as little as 20 centimeters, whereas at the easternmost of our survey sites the total depth of the stratigraphic sequence is nearly 3 meters. The Aguacate has generally been regarded as a culturally sterile substratum. However, during test excavations at site G–175, a pitlike feature extending into the Aguacate was found; artifacts were also found *in situ* in the top of the Aguacate at several survey sites. Evidence from both survey and excavation thus indicates that this assumption may be in need of reevaluation.

Topography of the area surrounding the Laguna de Arenal varies widely. There is a general east-west trend, with steeply sloped to mountainous terrain in the eastern portion of the region grading into more gently rolling hills at lower elevations at the western end of the lake. This general trend is subject to considerable local variation, however. Prior to filling of the laguna, the Rio Arenal drained not only the ancient lake but also a fairly wide and flat river valley with an extensive tributary system to the east. The Rio Arenal forms part of the drainage system of the Rio San Carlos, which in turn is a major tributary of the Rio San Juan. This river empties into the Atlantic Ocean and today forms the political boundary between Nicaragua and northeastern Costa Rica.

Although hydrologically part of the Atlantic Watershed, the Cuenca de Arenal is a microcosm of the general east-west climatic gradient seen throughout northern Costa Rica. Within the cuenca, there is a pronounced climatic gradient from the "Pacific regime" with more distinct seasons and lower rainfall in the west to the "Atlantic regime" with increasing rainfall and less seasonality in the east. Local variations may be rather dramatic, however. This variability is in part a reflection of the geographic location of the cuenca in a tectonic depression between the Cordillera de Guanacaste and the Cordillera de Tilarán where the two climatic regimes meet. Local conditions such as elevation, slope, temperature, exposure to seasonal winds from the southwest, force of the wind, and solar radiation also contribute to this variability.

SURVEY STRATEGY AND METHODS

The survey was conducted from March 20 to April 4, 1984 and covered approximately 63 kilometers of the shoreline of the Laguna de Arenal, from the Quebrada Garrapaton on the northern shore, around the west end of the lake, and along the southern shore to a point approximately 3 kilometers east of the mouth of the Rio Chiquito. This distance was traversed on foot by a team of 2 or 3 archaeologists and 2 or 3 local workers. The area surveyed was essentially a transect of the sites discovered, the width of which was determined by the distance from the shore of the lake to the eroded cut bank.

There were, of course, areas which were impassable on foot due to density of vegetation or marshy terrain. Such areas were usually encountered near the numerous quebradas which drain into the laguna. Other areas were in fact traversed but the subsurface had not been exposed by erosion and, hence, it was not possible to determine whether or not sites exist at these localities. Approximately 13 kilometers of the shoreline was so designated. Thus, the effective shoreline distance where the presence or absence of sites could be determined was approximately 50 kilometers.

Survey methods were determined by first assessing the relative extent and density of cultural materials. Cultural materials were then assigned to one of four classifications: 1) Large sites: relatively dense concentrations of artifacts (over 100), usually spread over a fairly large area of ground surface, 2) Small sites: lesser concentrations of artifacts (30-100) and covering a smaller area. These two categories have definable boundaries within which there is a greater concentration of artifacts. 3) Sherd scatter: a light concentration of artifacts, usually less than 30 sherds, 4) Isolated finds (IF's): an isolated finished artifact or a very small number of diagnostic ceramics (less than 10) and any associated cultural material.

Procedures for recording and making collections differed according to these classifications. For all sites the first step was to determine the extent of the site. UTM coordinates were then recorded and locations plotted on 1:50,000 Tilarán or Arenal quadrangle maps.

Isolated finds were collected. Notes were taken, and Lot cards were filled out for each IF.

Observations about sherd scatters were included in field notes, but no collections were made. Although these sherd scatters often included some lithics, no scatters of predominantly lithic artifacts were found.

For all sites, a sketch map was drawn. Length and width of the site were determined by pacing. The cut bank, or an eroded section of the shoreline, was cleaned and profiles measured and drawn to record stratigraphy. Observations of strata in both the cut bank profile and the eroded section of the shoreline were compared with the regional stratigraphic sequences in order to determine in which strata artifacts were embedded and from which strata artifacts on the surface were most likely eroding. A representative sample of fire-cracked rocks of various sizes was gathered, and total number of such stones counted. Photos were taken and sites were recorded on site forms provided by the Museo Nacional.

Collection methods differed for large and small sites. In both cases, special collections were made of any concentrations of artifacts and designated as Lots A-3 through A-n. Examples of such collections would be a concentration of chipped stone, or of sherds believed to belong to a single vessel, collections from profiles, and collections of artifacts *in situ*.

On small sites, all artifacts observed on the surface were collected. This general collection was designated Lot A-1, and included all diagnostic ceramics, all chipped stone artifacts, and all groundstone artifacts.

For large sites, areas of special collections were first designated. A 100°/o sample, Lot A–2, of a representative area of the site was then collected until a given volume of artifacts was collected (half of a large bag); this collection was usually made as a 1 meter wide transect of the site. Following this, the general surface collection was made. For sites with an especially high density of artifacts, where it would have been infeasible to collect all diagnostic ceramics, we selected a wide variety of diagnostic ceramics.

Data on a number of environmental variables which could be expected to influence settlement patterns were also obtained. On-site measurements of the slope of the site from the cut bank were made with a Brunton compass at representative locations. Where topography changed rapidly, several measurements were taken. Field notes included information on topography, surrounding vegetation, and probable extent of the site beyond the shoreline where possible. Additional information on landforms and access to water was gathered from previous versions of the Tilarán and Arenal quadrangle maps, which show former river courses and the old lake shoreline.

Field assessments of stratigraphic levels were based on the Silencio and Tilarán stratigraphic sequences (Article 3). Knowledge of the regional stratigraphy based on observations from both excavations and road cuts was combined with on-site observations of strata, and examination of soil and tephra samples with a microscope in the field laboratory, to establish stratigraphic correlations between sites and with the El Tajo sequence.

The Silencio sequence is used for sites G-156 through G-161, and sites G-171 through G-177. These sites are in the eastern half of the survey area, closer to Volcán Arenal. Here Units 20 and 41 are distinctive and readily recognizable, allowing us to distinguish between Unit 30 and the Unit 50 Complex. Presence or absence of artifacts in either or both of these units could then be used to infer whether a site was a single component site or a multicomponent site. Finer stratigraphic divisions within the Unit 50 Complex defined in the Silencio sequence were seldom discernible along the eroded shoreline.

The Tilarán sequence (Article 3) was used for stratigraphic designations at sites G–162 through G–165, and G–167 through G–170, in the western half of the survey area. At all of these sites erosion has exposed the Aguacate, but the complete sequence is present at none of these sites. Hence, the identification of a particular Black or White layer in the field was dependent on observation of dacitic pumice which is characteristic of White 3 and correlated with Unit 7 at El Tajo (Article 3). This distinction is not always possible in the field.

The entire Tilarán sequence predates Unit 41 in the Silencio sequence and is characteristic of a different mode of eruption for Volcán Arenal. Longer, less violent eruptions of finer tephra probably typified this phase. It precedes the pyroclastic eruptions of dacitic pumice typical of Arenal's more recent history (Melson, personal communication 1984).

RESULTS

Of the 22 sites recorded during the survey, 20 are located on the lakeshore. One (G–166) is an island which was surveyed in the same manner as small sites on the shore (except for transportation to the site!). Another, G–169, is located on a ridge above site G–156; the owner of the property on which this site is located informed us of some previous finds on his land and allowed us to conduct test excavations there with very promising results (Article 5).

No sites were found along the northern shore. However, the distance surveyed in 1984 was small and geological processes are not conducive to finding sites here. Because the dominant winds from the northwest drive the waves of the lake to the southern shore, eroded areas along the northern shore tend to be small and erosion shallower than along the southern shore.

Fourteen sherd scatters were noted during the course of the survey, and it is possible that some of these actually are derived from small sites. However, no cultural materials were found *in situ* at any of these locations. Nineteen isolated finds were also found and collected.

Site distributions and environmental factors

In attempting to reconstruct the prehistoric environment and potential resources of the Cuenca de Arenal, the 512 meter lake level has been used as a guideline for possible prehistoric topographic relationships. Locations of sites in relationship to this lake level, former landforms and permanent water resources are shown in Figure 1.

The ecological relationships between climatic variability, undisturbed vegetation and land use potential within the Cuenca de Arenal can be explored with reference to data from meteorological stations and the Holdridge Life Zones, or "bioclimates." Each life zone contains unique ecosystems with distinctive environmental conditions and associations of plants and animals. The primary vegetation in each bioclimate is determined by the seasonal variation and distribution of temperature and rainfall (Hartshorn 1983). Each life zone could thus be expected to have a different resource potential which would have affected prehistoric adaptations. There are two major life zones within the survey area.

Of the 20 shoreline sites, 17 are in the eastern half of the survey area. Thirteen are located along a stretch of shoreline approximately 15 kilometers long between the Rio Tronadora and Rio Chiquito. Of the 7 sites to the west of the Rio Tronadora, 4 are within 15 kilometers of the Rio Tronadora and only 3 are located farther west. Sites G–167 and G–168 at the far west end of the lake may actually be part of the same site. They are separated by a large dike of boulders supporting the road around the lake.

For most of the sites on the shoreline (17 out of 20), the distance to water from permanently flowing rivers or quebradas is less than the distance from the lake. Only one site (G–170) –and of course the island (G–166)– is located closer to the lake than to a perennial source of running water (See Table 1). Slopes throughout the area range from 7 to 18 degrees. In only one instance (G–162) was the slope greater than 20 degrees.

The topography of the area between Rio Tronadora and Rio Chiquito, where the greatest concentration of sites is located, is mountainous with numerous "quebradas" cutting steep-sided hills of 700-900 meters in elevation, and forming ridges 500-600 meters in elevation as they reach the lakeshore. Sites G–171 through G–175 are located on slopes about 20 meters below the crest of such ridges. Today these are points of land exposed to erosion. Large sites in this area wrap around the points on which they are located, indicating that the sites themselves probably include the ridge tops. The ridges on which these sites are located overlook the alluvial plains of the Rios Arenal and Chiquito, or one of their tributaries. Sites G–176 and G–177 are situated on the alluvial terraces of the Rio Chiquito.

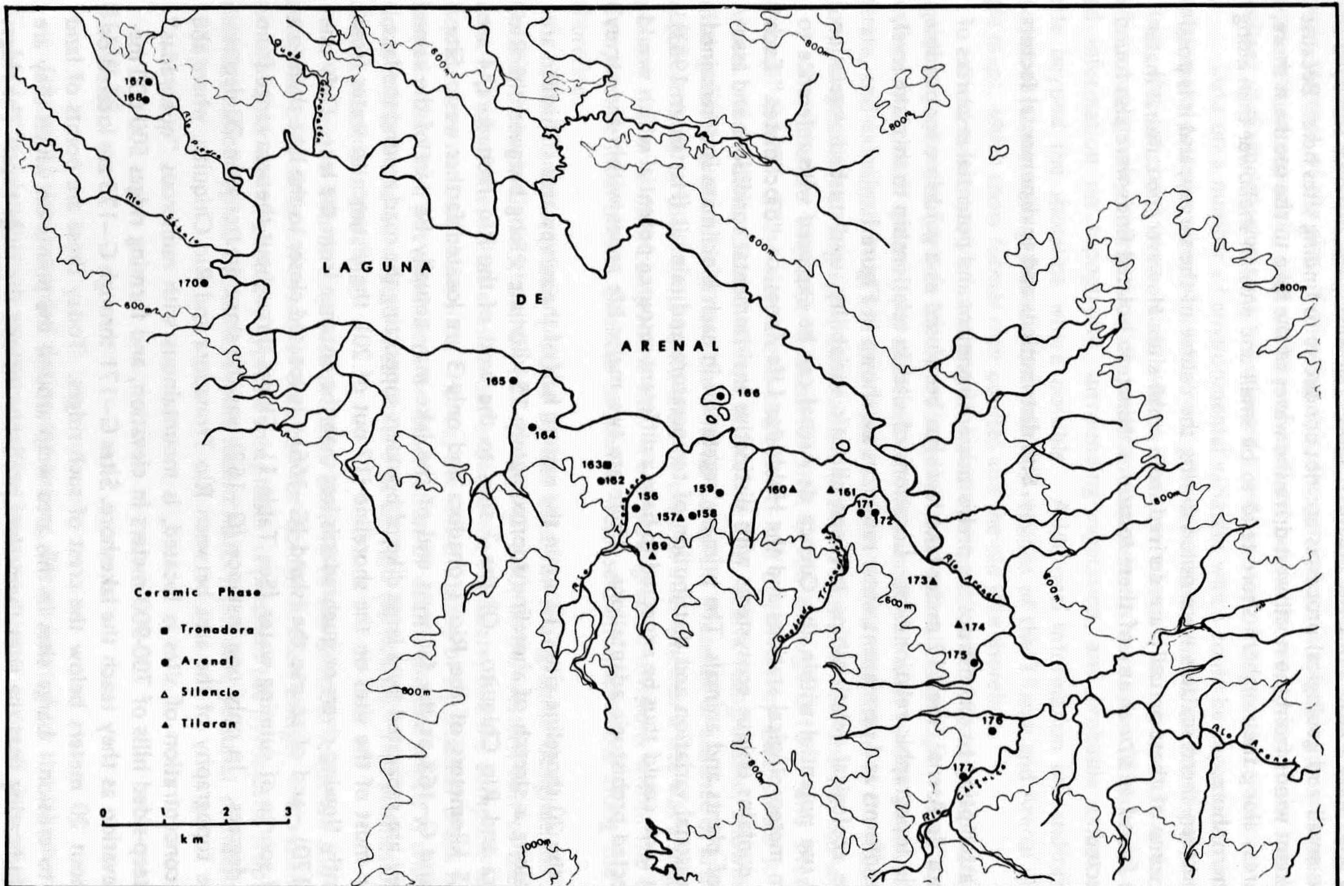

Figure 1. Location of sites discovered during the shoreline survey of Laguna de Arenal in relationship to former lake level (512 m), landforms and permanently flowing water. The predominant ceramic phase at each site is indicated.

Sites G–171 through G–177 are in the *Bosque muy húmedo Premontano* (tropical premontane wet forest) life zone. Original vegetation was probably a medium to tall semievergreen forest with a few dry season deciduous species (Hartshorn 1983). Data from meteorological stations indicate that rainfall ranges from 2800 mm annually at Arenal Viejo, near Site G–174, to 3333 mm of annual precipitation at Rio Chiquito, near sites G–176 and G–177. At Arenal Viejo, there are 11 wet months and one month of excessive precipitation, and no dry months. Moving east and south to Rio Chiquito, there is one dry month, 5 wet months and 6 months of excessive moisture (Tosi 1980).

This life zone belongs to the perhumid province which is highly productive for tropical forests, but has some limitations for agriculture. During months of excessive rainfall, soils may become saturated, and anerobic soil conditions may develop, making the soil difficult to work. During this period, open fields are subject to massive erosion, especially on steep slopes. The soils are generally low in fertility and very acid, except in terrain with low slopes or exceptional fertility, such as alluvial soils (Tosi 1980). All of the sites in this zone have access to such alluvial soils. On the flood plain of the Rio Chiquito, where sites G–176 and G–177 are located, the land is subject to severe erosion and occasional inundations, however. Crops that cannot tolerate a pronounced dry season are best adapted to this area, whereas seed crops such as maize which require a dry season may be less well adapted to such a region.

The 10 sites between G–165 on the west and G–161 in the east are located on points of land, hillsides or small coves today, but before the filling of the lake they would have been in the area of transition between the steep hills to the south and broad flat plains stretching north from the foothills to the lakeshore. G–160 and G–161 would have been on large relatively flat benches. West of the Rio Tronadora, the terrain becomes gradually less mountainous, although slopes in this region can be very steep. Four of these sites (G–162 through G–165) are located in this hilly terrain north and west of the Río Tronadora.

The three sites at the western end of the lake are located on piedmont slopes. The relief in this area is strongly undulating, but the elevation of the surrounding hills seldom exceeds 700 meters. It is at this end of the lake, where slopes are gentler and the depth of the lake shallow, that the former lake was marshy (Tosi 1980).

All of the sites between the Rio Piedra at the west end of the lake and Quebrada Tronadorcita in the east (site G–167 at the west end of the lake through site G–161 in east) are in the *Bosque húmedo Tropical, Transición a Premontano* (tropical moist forest, premontane belt transition) life zone. Sites G–166 and G–169 are also in this life zone. The original vegetation of this life zone would have been tall, multistoried semideciduous or evergreen forest (Hartshorn 1983).

The climatic gradient within the cuenca is apparent even within this single life zone. Meteorological data from Rio Piedras and Naranjos Agrios, near sites G–167 and G–168, show that this area has a dry season of 2 to 4 months, a wet season of 7 to 10 months, and at most one month of excessive rainfall. In the same life zone but farther east, sites near Tronadora receive slightly more rainfall than the westernmost sites, but lack a real dry season. This area is more affected by humid winds from the Atlantic. Eleven months of wet weather and one of excessive precipitation have been recorded in this area. Annual precipitation is 2233 to 2440 mm at the western end of the lake, increasing to 2600 mm at Tronadora. Losses to runoff are low compared to total precipitation.

This is one of the life zones of the humid province. Life zones of this province

Table 1. Topographic, climatic, stratigraphic and artifactual data by site

Site	Landfrom	Slope	Distance to Lake	Distance to Permanent Water	Life Zone	Strata	Dominant Ceramics
G156	Foothills	9	1.1 km	50 m	Bh–T	Unit 30	Arenal
						Unit 50	
G157	Foothills	18	1.0 km	500 m	Bh–T	Unit 30	Silencio
G158	Foothills	17	1.05 km	600 m	Bh–T	Unit 50	Arenal
G159	Foothills	12–17	700 m	350 m	Bh–T	Unit 30	Arenal
G160	Bench	12	600 m	400 m	Bh–T	Unit 30	Tilarán
G161	Bench	12	450 m	300 m	Bh–T	Unit 30	Tilarán
						Unit 50	
G162	Foothills	23	700 m	450 m	Bh–T	1st Black	Arenal
G163	Foothills	7	750 m	750 m	Bh–T	1st Black	Tronadora
G164	Foothills	7	350 m	350 m	Bh–T	1st Black	Arenal
						White 2	
						Black 2	
						White 3	
G165	Foothills	12	300 m	200 m	Bh–T	1st Black	Arenal
						White 2	
						Black 2	
G166	Island	nm	50 m	1.05 km	Bh–T	Unit 30	Arenal
						Unit 50	
G167	Piedmont	17	1.95 km	50 m	Bh–T	Top of Aguacate	Arenal
						1st Black	
G168	Piedmont	12–15	1.7 m	200 m	Bh–T	Top of Aguacate	Arenal
						White 1	
						Black 2	
G169	Ridge	nm	600 m	50 m	Bh–T	na	Tilarán
G170	Piedmont	12	200 m	450 m	Bh–T	1st Black	Arenal
G171	Ridge	17	550 m	150 m	Bmh–P	Unit 30	Arenal
G172	Ridge	18	250 m	300 m	Bmh–P	1st Black	Arenal
G173	Ridge	12	400 m	400 m	Bmh–P	Unit 30	Tilarán
G174	Ridge	13–17	1.7 km	450 m	Bmh–P	Unit 30	Silencio
G175	Ridge	10–14	2.1 km	50 m	Bmh–P	Unit 50	Arenal
G176	Alluvial terrace	10	3.1 km	200 m	Bmh–P	Unit 30	Arenal
G177	Alluvial terrace	10–13	4.25 km	50 m	Bmh–P	Unit 30	Arenal
						Unit 40	
						Unit 50	

Note: Permanent water refers to permanently flowing rivers or quebradas
Bh–T = Bosque húmedo Tropical, Transición a Premontano
Bmh–P = Bosque muy húmedo Premontano
Strata refers to strata in which artifacts *in situ* were observed.

offer almost ideal conditions for agriculture, with sufficient soil moisture even in the dry season. Compared to the more humid bioclimates, such as the *Bosque muy húmedo Premontano* life zone in which sites G–171 through G–177 are located, the soils are relatively fertile, less acid and higher productivity can be maintained. The soils, long hours of sunshine, and relatively low humidity make the region well-suited for cultigens with a short growing season. Although suitable for cultivation, the land on which sites near Tronadora or farther east are located is more favorable for permanent or semipermanent cultigens (Tosi 1980). When cultivated using methods which do not involve a great deal of soil reworking, maize and beans can be considered semipermanent crops (Tosi 1980). Most Precolumbian agricultural practices, such as swidden agriculture, could probably be placed in this category. However, the practice of burning fields before planting, typical of maize agriculture in much of the New World, subjects the soils of this area to potentially severe erosion (Tosi 1980).

The erosional environment of the survey area can result in problems as well as advantages for the archaeologist. The areal extent of sites cannot be determined from a shoreline transect. The proportion of a site that had been inundated was impossible to calculate and, except at those sites selected for test excavations, we have not yet attempted to define the extent of the sites beyond the shoreline. Relative comparisons of site sizes made on the basis of the maximum extent of cultural materials along the eroded shoreline thus may not be representative of actual site sizes. We were therefore unable to establish any sort of site hierarchy. Nor can we totally eliminate the possibility that the estimated size of a site is, at least in part, a function of geological processes.

Architecture is lacking and features, if they survive, can be difficult to recognize in an erosional environment. In fact, no definitely cultural features were recorded during the survey. The only clues as to whether or not a site was a habitation site were rather scanty surface collections of groundstone artifacts such as manos and metates, chipped stone, and domestic ceramics.

Manos or metates were collected at several sites. All showed evidence of use (Article 11), but whether in a domestic or ceremonial context cannot be determined. Groundstone celts, or hachas, were also found at a numer of survey sites. These tools are frequently interpreted as indicating woodworking activities such as forest clearing at habitation sites. Combining this information with that from lithic analysis of chipped stone (Article 10), available data indicate that three sites have both groundstone and chipped stone artifacts that are usually associated with domestic activities. These sites are G–156, G–161, and G–163. These were among the sites selected for test excavations. Data from ceramic assemblages which might support the supposition that these are habitation sites are not yet available.

Two sites, G–166 and G–164, have been identified as cemeteries. Both may have habitation areas as well.

Ceramic chronology and stratigraphic correlations

Middle Formative Tronadora Phase ceramics represent the earliest settlements in the Cuenca de Arenal, and are dated from 1000 to 500 B.C. This phase comprises the major ceramic component only at Site G–163. They are almost as abundant as Arenal Phase ceramics at Site G–162, however (with 41 percent Arenal Phase ceramics and 36 percent Tronadora).

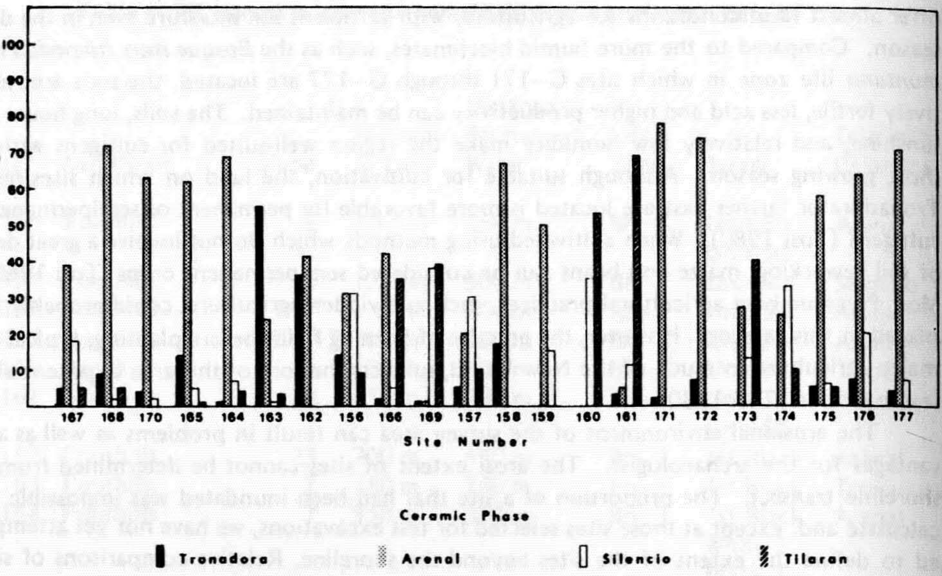

Figure 2. Percentages of ceramic phases at lakeshore sites. Site numbers are arranged geographically, from west to east.

At 14 of the 20 shoreline sites, and at the island site G–166, Arenal Phase ceramics, dated from 500 B.C. to 500 A.D., are the major component, and percentages of this phase in the individual site assemblages tend to be high (Fig. 2). At Site G–156, ceramics from excavated and survey lots combined show equal percentages of both Arenal and Silencio ceramics. However, ceramics from escavated lots are predominantly Arenal Phase and no Silencio Phase ceramics were recovered from excavated units.

Locations of Arenal Phase sites appear to be related to topography. The three sites in the western half of the survey area are all Arenal Phase sites; all are located on wide piedmont slopes. Sites G–167 and G–168 are farther from the old lakeshore than any other sites. This may be related to the marshiness of the edge of the lake at this end. Twelve of the 15 Arenal Phase sites are located in the eastern half of the survey area, and 8 of these 12 are in the "intermediate" hilly zone to the west of Quebrada Tronadorcita. There does not seem to be any relationship between the life zones and site locations, although access to resources from the higher altitudes just south of these sites may have been a factor. Such resources might have included wild game and tree and root crops.

Arenal Phase sites in the eastern part of the survey area, where the Silencio stratigraphic sequence is clearest, were observed to have artifacts *in situ* in the Unit 50 Complex. At sites where the Tilarán stratigraphic sequence was used, artifacts were found in the top of the Aguacate, Black 1, White 2, and/or Black 2. Arenal Phase ceramics predominated in only three cases where artifacts were observed eroding from Unit 30. The presence of early ceramics in more recent strata could be explained by a number of factors. One of these sites (G–159) has been greatly disturbed by construction activities; disturbance or reworking of soils at other sites through cultural activities or natural processes such as rodent disturbance may also have occurred. The Arenal Phase spans a long time and it is possible that either stratigraphic associations or ceramics were misdiagnosed.

Sites at which Silencio (600 to 1000 A.D.) or Tilarán (1000 to 1500 A.D.) Phase ceramics are the major components are conspicuously fewer. Most of these sites are located between the Rio Tronadora and Quebràda Tronadorcita. Silencio Phase ceramics are primary only at sites G–174 and G–157. At only three sites along the lakeshore are Tilarán Phase ceramics the primary component. Generally, Silencio and Tilarán Phase ceramics have been found as major and secondary components at the same sites. Only at G–173 and G–166 are Arenal Phase and Tilarán Phase ceramics the dominant major components, with very low percentages of the intervening Silencio Phase ceramics. The G–169 ceramic assemblage contained 39 percent Tilarán and 28 percent Silencio ceramics.

Stratigraphic observations made at Silencio and Tilarán Phase sites consistently indicated the presence of artifacts in Unit 30.

Test Excavations

Several sites located by the survey were selected for test excavations during the 1984 field season. Sites G–156 and G–161 were chosen because surface collections and stratigraphic observations indicated that they might be multicomponent habitation sites. G–163 was selected as a probable single component Formative site, and thus far is the only site at which Tronadora Phase ceramics are dominant. It also seems to be a habitation site. A projectile point probably dating to the Archaic period was also found at this site (Article 10). G–175 was tested to examine the hypothesis that it is a multicomponent site with a Formative component and a Zoned Bichrome/Early Polychrome transitional phase. Posthole survey of site G–169 revealed a high density of ceramics and a likely habitation site. Details of these investigations are presented in Article 5 of this volume.

Several other sites of interest have yet to be test excavated. One of these is site G–164. This site had an exceptionally high artifact density. On the hill above is a prehistoric cemetery. The extent of the cemetery has not yet been determined. The ceramic assemblage showed tremendous variety, including fine-paste wares and types similar to Atlantic styles or trade wares, as might be expected at funerary sites (Snarskis, personal communication 1984), and domestic wares (Hoopes, personal communication 1984). A fragment of a serpentinite pendant found at this site also implies external contacts, either by trade or direct procurement, for the Cuenca de Arenal (Article 12). The site includes several lithic concentrations. *In situ* cultural materials can be found in the five lowest stratigraphic levels.

Site G–170 was not actually found during the course of the survey, but about 2 weeks later during a geological reconnaissance, at which time the lake level was considerably lower. This is a large site at the west end of the lake, and appears to be a single component site of the Arenal Phase. All materials found *in situ* came from the first Black soil above the Aguacate.

DISCUSSION AND SUMMARY

The earliest settlement in the Cuenca de Arenal for which we have evidence is Late Period IV, Tronadora Phase (1000–500 B.C.). However, the surface find of a probable

Archaic point at Site G–163 raises the possibility of an even earlier occupation.

Ceramic evidence points to a fairly heavy population on the slopes around the lake during the Arenal Phase, which corresponds to Late Period IV (300 B.C. to 500 A.D.). This hypothesis is supported by data from previous surveys in the Cuenca de Arenal. Murray found Zoned Bichrome sites along the shore at the 512 elevation level at the western end of the lake (Article 1). Several sites within the now-inundated part of the Rio Arenal valley, including El Tajo, also were designated as Zoned Bichrome sites (Aguilar 1984). Two other surveys have been conducted in the highlands of northwestern Costa Rica. Survey data from the Rio Naranjo/Bijagua Valley in the Cordillera de Guanacaste, an area similar to the Cuenca de Arenal in terms of both topography and climate, indicated that population levels were highest during the Zoned Bichrome period, although the area was occupied earlier (Norr 1982). Sites at Hacienda Jerico, on the western slopes of the Cordillera de Guanacaste, were also dated to this period and the Early Polychrome (Finch 1982).

The role which the resources of the lake itself or volcanic processes contributing to soil fertility may have played in these developments has not yet been fully explored. Tectonic depressions, especially when related to water resources or trade routes, may well have been important factors in settlement patterns and population density throughout Precolumbian lower Central America (Lange 1984b). Both are possibilities for the Cuenca de Arenal.

The increase in population during Late Period IV parallels developments in other areas of Costa Rica. In the Greater Nicoya subarea, population increased and mortuary data indicate social stratification and at least low level chiefdoms. Subsistence data is rare, however, until the later part of this period. At that time there was a marked shift to coastal adaptations and exploitation of marine resources (Lange 1984b). On the Atlantic Watershed, this was also a time of increased population growth and sites from this period are numerous and large, usually situated on fertile plains or valley floors. As in Guanacaste, a ranked social structure is indicated. Direct evidence for maize cultivation has been obtained from several sites (Snarskis 1981a, 1984). While our evidence of increased population levels during Late Period IV accords well with that from others areas, the very limited data available on subsistence (Article 13) and social structure precludes comparison with other cultural and social developments at this time.

Population of the area seems to have declined dramatically during early Period V (600 A.D. to 1000 A.D.) and remained low through late Period VI (1000 A.D. to 1500 A.D.). Whether this phenomenon is related to volcanic activity has not yet been investigated. A similar decrease in population also seems to have occurred in the Rio Naranjo/Bijagua Valley, with some sites approaching abandonment (Norr 1982).

This contrasts with general developments in other areas of Costa Rica. In the Greater Nicoya, population growth continued and Middle Polychrome sites are numerous; sites continue to be concentrated along coastal embayments through Period VI (Lange 1984b). In the Atlantic Watershed, dispersed villages located on alluvial terraces continue during Period V (Snarskis 1981), but again there seem to be fewer sites (Snarskis 1984). During Period VI there are numerous but relatively small, agglomerated villages located on the fertile plains and valleys of eastern central Costa Rica (Snarskis 1984).

With only very limited data available on site locations before the construction of the Sangregado dam, and lacking data on wider regional patterns, determining critical factors in settlement patterns is difficult. We can only address the question of settlements within the cuenca itself at the 540 meter elevation. Here, important factors in the selection of settlement locations seem to have been access to rivers and flat land, although access to resources of the adjacent highlands may also have been a factor. The majority of sites found by Aguilar (1984) were located near tributaries of the Rio Arenal. This seems to agree with the general pattern implied by our data.

At first glance it may seem that in terms of climate and topography the greatest concentration of sites is located in the least favorable area. In terms of agricultural potential, sites in the eastern sector are in an area limited by both climatic and topographic factors, whereas those at the western end of the lake are favorable in climate and limited mostly by local topographic factors. However, the easternmost sites have access to the alluvial plains below and because of their elevated locations probably were not subject to periodic inundation. The distribution of sites at the west end of the lake may also be somewhat misleading. It indicates only the distribution of sites at the 540 meter lakeshore. If the distribution of sites along the old lakeshore were known, it would be possible to present a more realistic view of prehistoric occupation of this area.