Chapter 7

Creating and Perpetuating Social Memory Across the Ancient Costa Rican Landscape

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Abstract: For most of the time that Native Americans lived in ancient Costa Rica, we think their travel across the landscape was task-oriented and thus sufficiently randomized to leave no detectable trace. That changed about 500 B.C. in the Arenal area when people separated their cemeteries from their villages, and travel between them was ritually mediated into travel precisely along the same path, in single file, in as straight a line as possible. The inadvertent erosion over centuries of use resulted in paths entrenching to 2 m or more deep. We believe the cultural standard developed over the centuries was that the preferred way of entering a special place was by an entrenched path. Thus, people approaching a special place would have a highly restricted view of their surroundings, but upon entering the special place, it would dramatically open up to view. People created and perpetuated social memory across their landscapes with generation after generation of use. The construction of meaning developed as the paths entrenched, ultimately embedding that meaning deep in people's belief systems as their pathways were embedding themselves into the landscape. Although chiefdoms never developed in the Arenal area, a series of chiefdoms did develop east of the area at about A.D. 1,000. To satisfy the emergent chief's needs for monumentality, we suggest here that chiefs chose the "proper entrenched entryway" as exemplified in the Arenal area, for elaboration. On the rocky slopes of the volcanoes monumental entryways were built of stone, and on the fine-grained alluvial plains they were of earthen construction. For instance, the radiating entrenched roads entering Cutris are many meters long, as wide as 50 kilometers, and many meters deep.

1. INTRODUCTION

The Proyecto Prehistorico Arenal has been conducting research in northwestern Costa Rica since the mid 1980s, documenting Native American occupation from about 12,000 years ago to the Spanish Conquest. Most of the research objectives, methods, and results are presented in Sheets and McKee (1994), with earlier research results presented in Sheets and Mueller (1984). The previous publications dealing with remote sensing in the Arenal area include McKee and Sever (1994), McKee et al. (1994), Sheets (1994a, b), Sheets and Mueller (1984), Sheets and Sever (1988, 1991), and Sever (1990). Publications on relevant archaeology include Bradley (1984, 1994), Bradley et al. (1984), Chenault (1984), Hoopes and Chenault (1994a, b), and Mueller (1992, 1994).

Evidence of PaleoIndian and Archaic occupations has been found, with sedentism achieved by 2,000 B.C. Four phases of sedentary occupation have been defined, with societies in all phases remaining egalitarian, or slightly pushing the boundaries of egalitarian organization. Compared to other areas of Middle America, population densities remained slight, agriculture minimal, and social stability remarkable over long periods of time. The avoidance of complex society, competition, and warfare contributed to social stability.

In the project's second year a collaboration was established with Tom Sever of NASA for remote sensing. If remote sensing for archaeology could be successful in the Arenal area tropical rainforest with minimal human impact on the ancient environment and multiple layers of volcanic ash draping the landscape, then it was believed that it should be applicable to other areas. Many kinds of analog and digital remote sensing imagery have been used in the research area. The most important, and wholly unanticipated, remote sensing success was detecting ancient footpaths as linear anomalies. The reason we have not been able to detect ancient paths for most millennia of native occupation, we believe, is because people had no need to walk along precisely the same line for decades. However, ancient footpaths are detectable for almost two millennia, beginning about 500 B.C. When people separated cemeteries from their villages, they followed ritually prescribed routes single-file to connect these two special places. The sustained use of these paths had unanticipated erosional and entrenching effects that, we believe, led to their becoming the favored entryways into special places. Later chiefdoms "writ large" these entrenched paths into monumental and very impressive entryways into their central places.

2. RESEARCH BACKGROUND

2.1. Arenal Research Project

In the early 1980s, Payson Sheets decided to investigate the relationships among egalitarian peoples, explosive volcanism, and tropical rainforest environments in the Arenal area of Costa Rica (Figure 1). He received funding

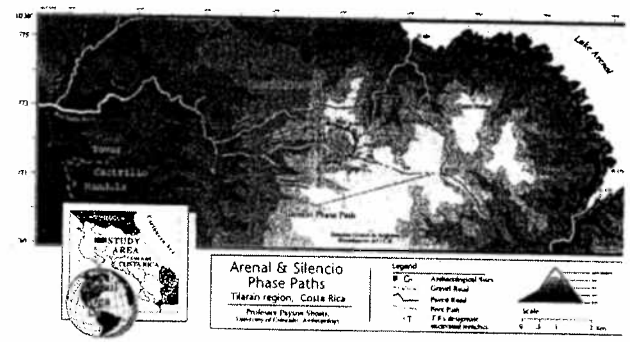

Figure 1. Map of the Arenal research area in Northwestern Costa Rica. The eastward Silencio phase path might lead from the cemetery to the village sites on the shore of Lake Arenal. The westward Silencio phase path does lead to the Tovar source of stone for tomb construction, just west of Tilaran. The earlier Arenal phase path leads from the G-156 village on the lake shore westward to the cluster of cemeteries in the Castrillo and Mandela area.

from the National Science Foundation and National Geographic Society for a few seasons of fieldwork, beginning in 1984. The only form of remotely sensed imagery used during the first field season was commercially available black-and-white aerial photography from the local Instituto Geografico, in the form of 9" × 9" contact prints and enlargements. The first season was successful in establishing general phases of occupation (see next section), and in documenting settlement patterns during the past four or five millennia of sedentary occupation (Sheets and McKee, 1994).

Independent from, but concurrent with the first field season at Arenal, Tom Sever at NASA and John Yellen at the National Science Foundation were looking for a regionally oriented research project that might benefit from remote sensing enrichment. When that was offered to Sheets, it took less than a nanosecond to accept, and the project research was permanently transformed. Remote sensing for archaeological objectives was seen as challenging in the Arenal area, because population densities were minimal compared to other areas of Middle America, human impacts on the environment were slight, the tropical rainforest or heavy pasture grasses obscured the ground surface, and multiple layers of volcanic ash buried the ancient ground surfaces.

Arenal volcano erupted explosively some 10 times during the past 4,000 years (Melson, 1994), deeply burying many archaeological features, and making remote sensing for evanescent features difficult in many areas. However, the volcanic ash (tephra) layers provided invaluable time-stratigraphic horizon markers for dating footpaths that have virtually no associated artifacts.

The radiocarbon-dated tephra layers provided a means of dating ancient footpaths or other phenomena forming linear anomalies, after the anomaly was detected in the analog or digital remote sensing imagery (see below). Excavations and stratigraphic interpretations could identify the paleosol that was contemporary with the initiation of path use. The ending of path use is dated by the tephra layer that uniformly covered the path, with no evidence of the erosion that resulted from continued use (see McKee et al., 1994, for details of methodology, assumptions, path formation, and preservation, and other key issues). Thus we can date ancient paths to a particular archaeological phase, or in the case of 19th-century ox-cart roads or more recent features, the stratigraphy clearly distinguishes Precolumbian linear features from historical and recent ones. The criteria we developed for dating the various linear features, from ancient to recent, are presented in McKee et al. (1994).

It is important to point out that, in all the years of excavations into confirmed ancient paths, we have yet to find a single instance of deliberate construction activity. The actual path surface upon which people walked is rarely wider than a half meter, but the erosional effects on sloping terrain routinely affect 2–4 m on each side of the path, resulting in a linear erosional feature wide enough to be detected quite readily in medium-resolution imagery.

2.1.1. *Phases of Human Occupation*

People have lived in the Arenal area for approximately 12,000 years, and for ten of those 12 millennia they left no traces of human movement across the landscape that we have been able to detect. A Clovis-style projectile point found on the south shore of Lake Arenal is clear evidence of PaleoIndian occupation about 12,000 years ago, and occasional Archaic projectile points and campsites were found in the area, dating to 5,000 bp and earlier (Sheets, 1994). The first phase with semi-sedentary to sedentary villages is the Tronadora phase, beginning possibly by 3,000 B.C., but certainly by 2,000 B.C. (Sheets and McKee, 1994; Hoopes, 1994c) and ends at 500 B.C. Burials during the Tronadora phase were adjacent to the house, in small pits that presumably were for secondary burials, along with ceramic vessels as grave goods. The very moist, acidic soils do not preserve ancient human bones or teeth in this area, with the sole exception of the Silencio phase (see below), when stone boxes were built as tombs that protected the skeletons. All kinds and scales of remote sensing imagery have been examined to try to find footpaths dating to any time during these ten millennia, and none have been found. We suspect that human travel across the landscape was task-oriented, in that when someone needed to collect some food, hunt, obtain water, or get some stone or firewood, they simply went there, got it, and returned. Task-orienting travel has a randomizing effect, leaving no long-lasting or permanent impact on the environment that we can detect. Surely this is fortunate, that our environment does not become permanently trampled by such travel. Our concern in this chapter is not to elucidate the nature of travel prior to the

Arenal phase, as we do not have direct evidence of it. Rather, our focus is the new structured kind of travel that emerged in the Arenal phase, its impact on the environment and its ideational implications, and finally how it may have become the seed for later monumentality in more complex societies.

In contrast to travel in preceding phases, a different kind of travel evidently developed during the Arenal phase, 500 B.C. to A.D. 600, when people evidently separated their villages from their cemeteries. We cannot claim that all Arenal-phase villages were separated from their cemeteries, but separation was common and routinized travel began to have repercussions that we can still detect today. A sense of place, and paths as sentient, may have been similar to what Snead (2002) found in the U.S. Southwest, and with the Yurok in northern California. For the Arenal research area, population densities were at their greatest during this phase, but when compared to other areas of Mesoamerica or the Andes, population was still sparse. Cemeteries show at least some indications of differentiation (Hoopes and Chenault, 1994a), and it is possible that society was pushing the boundary of egalitarianness. Cemeteries were built up of individual tombs made by hauling in large numbers of subrounded river rocks, with impressive remains of post-interment ritual, feasting, and breaking of ceramic vessels and occasionally elaborate metates (Hoopes and Chenault, 1994a). The new kind of travel linked cemeteries to villages, and people followed the same precise path generation after generation. The path itself was as straight as possible, denying topographic irregularities, and even going up and over a hill rather than around it in one case. The straight-as-possible walking along the same path created path entrenchments that were commonly 2 or 3 meters deep, and in some places much deeper (Figure 2). What we are suggesting here is that the inadvertent path entrenchment among these egalitarian Arenal-area societies began to create a cultural standard. We suggest that the "proper" way to travel between "special places," and to enter a "special place" such as a cemetery, was in an entrenched path, seeing little of the surrounding countryside while in transit. But when one walked into the cemetery, the path opens up into a dramatic broad vista. In a sense it is like the birthing process, or a rite of passage from one domain to another. We assume both villages and cemeteries were considered to be special places, and we believe what must have developed as people first separated villages from cemeteries is the concept that travel between them was a sacred act. Thus people created and perpetuated social memory by performing repetitive ritual travel that embedded itself deeper in the landscape through the generations.

The case of an Arenal-phase path going up and over a hill rather than around it is important here, as it informs us that people went out of their way to have an entrenched path, rather than following along the "path of least resistance" along the floodplain of the Rio Piedra. The associated Arenal-phase village (G-180) and cemetery (G-184) are 1.1 km apart, and the hill is just outside the village. As the path reached the top of the hill, it was no longer

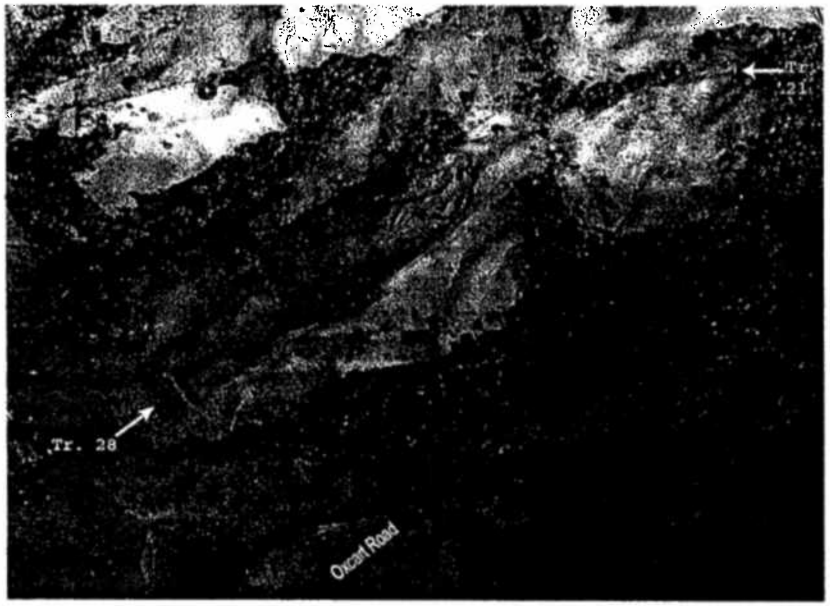

Figure 2. Color infrared airphoto taken in March 1985, rendered in black-and-white, covering 1.8 km horizontal distance. The Arenal phase footpath extends from Trench 21 down to Trench 28, where it was stratigraphically confirmed in both places. The path is double at Trench 21, but unites into one near the landslide scar in the center. An oxcart road from the late 19th and early 20th century is visible at the bottom.

incised because of the lack of erosional potential. People built two small stone features, which could be called platforms, of subrounded river cobbles on either side of the path. We found no evidence of burials there, but there were some broken pottery vessels, presumably indicating ritual activities, and it is tempting to envision rituals with mourners/celebrants passing single file between people standing on the stone platforms, supporting or somehow commemorating their passage.

Many other cases of entrenched pathways entering special places have been found during Proyecto Prehistorico Arenal research. The path that enters the Silencio cemetery (G-150) from the west is sunken, as are the three that enter that cemetery from the east. The four paths that arrive at the spring that supplied cemetery celebrants with water are sunken, as are the two that enter the spring from the east. The Arenal-phase path is sunken as it enters the village site (G-156) on the lakeshore. The two parallel Arenal-phase paths are sunken as they enter the Poma Cemetery (G-725, publications in preparation) and other cemeteries in the Poma area. And there are other apparent cases outside our research area, as exemplified by the Mendez site in the Rio Naranjo-Bijagua area 29 km north northwest of Tilaran (Norr, 1982). Sheets has detected a linear anomaly that appears to be an ancient entrenched path entering the Mendez cemetery from the north, and has inspected it on the ground, where it also appears to be an ancient eroded footpath. It has yet to be confirmed by excavations and analyses. Other sites such as Rivas (Quilter, 2004) have never been examined in aerial photography or other remote sensing imagery for evidence of possible footpaths (Jeffrey Quilter, personal communication, 2004), although Quilter is eager to have it done.

The physical phenomena of path formation and preservation are reasonably well understood (McKee et al., 1994). Compaction is the initial result of people walking along precisely the same path, which creates a linear depression. What we have found is that on slopes greater than 5°, and especially on slopes greater than 10°, erosion begins a progressive lowering, or entrenchment, of that path. The eastern end of the research area receives over 6,000 mm of mean annual precipitation, and the central area about 3,000, so there is sufficient moisture to do erosion on slopes where people were creating lines of susceptibility. The paths themselves were narrow, generally about 0.50 m wide, indicating single-file use was the actual and proper mode of transit. As the path itself became entrenched, the soil on both sides of the path was affected by the erosion. Because the tephra layers and soils are minimally consolidated in the Arenal area, the "angle of repose" is a widened "V" shape, generally sloping upward 25° to 30° from horizontal on both sides of the path (see McKee et al., 1994). In many places the modern land surface still retains the indentation of the ancient path, partially or largely filled in by later tephra deposits but still visible. In other places the entrenched path is entirely filled in by later tephra deposits, and it can only be detected by remote sensing sensitive to subtle vegetation differences, noticeable, in this case, because plant roots growing in the ancient path are in a sufficiently different matrix than plant roots on either side of the path. In this case color infrared aerial photography is the most sensitive remote sensing technique. When the paths traverse flat areas, they entirely disappear in all remote sensing imagery and from all indications in the field. Because flat areas are small and rare, and confirmed paths from different phases are generally far from each other, we usually can extrapolate from confirmed segments on both sides of the flat area, and continue to follow the same path. When we do extrapolations across flat areas we check stratigraphic indications especially carefully for synchronicity. Flat areas rarely extend for more than a few meters to tens of meters.

One challenge has been distinguishing ancient footpaths from historical-period and more recent features. Dating and stratigraphic interpretation procedures help distinguish linear anomalies such as ox-cart roads when lower elevations of the Arenal area were under sugarcane cultivation (McKee et al., 1994). Sugarcane cultivation, introduced from the lowlands to the west in the late 1800s, extended as high as 500–600 m and was cultivated as late as the 1950s. Ox carts were used as a common transport mode, and after an ox-cart road has been abandoned for a few decades, it can look much like an ancient footpath. A difference is the footpaths were routed as straight as possible, while ox-cart roads curved in response to topography.

Some aspects of funerary practices changed during the Silencio phase (Figure 3), A.D. 600–1300. Tomb construction turned to using the naturally flat-fracturing andesitic stone slabs called "*lajas*" and elongated "headstones" called "*mojones*." Sheets has observed the elongated "*mojones*" still in situ in looted graves in the Silencio cemetery. But what did not change was the ritually prescribed travel along straight-as-possible paths between villages and cemeteries. In the case of the Silencio cemetery, perched atop the continental divide, on the highest ridge in the area, the paths also led to a nearby spring used for drinking and cooking to support the impressive amount of feasting that took place (Figure 4). Three paths leading from the cemetery down to the spring can be seen in Figure 4, and each continues its arc under the rainforest canopy. One of the three splits into two just before entering the rainforest. All four come together at the spring. The other path from the cemetery, that heads westward, goes straight down a ridge and then makes an obtuse-angle bend to travel straight downhill. In that angle bend was a *laja* and headstone repository (Chenault, 1984; Hoopes and Chenault, 1994b), with stones placed here for intended future use. The path down the steep hill to the stream had eroded down to the pre-Arenal eruption clay-laden slippery "Aguacate formation" (McKee et al., 1994:147–149), and therefore they created a parallel path. Both paths emerge on the other side of the stream to climb the steep slope, and, after another obtuse-angle bend, head straight atop a broad sloping ridge toward the Pacific. Inside that second obtuse-angle bend is another *laja* and headstone repository. Because these repositories were both on the west side of the cemetery, we generated the working assumption that the source of *lajas* and headstones was to the west, along this path. That hypothesis was confirmed by geological field and laboratory research that chemically, petrographically, and morphologically confirmed the principal source at Cerro

Figure 3. IKONOS satellite image from March 2001, draped over digital terrain model, with Silencio-phase path indicated by dots. Horizontal distance covered in foreground is 4.8 km. The path heads to the Tovar source of stone for cemetery construction just off the image to the left.

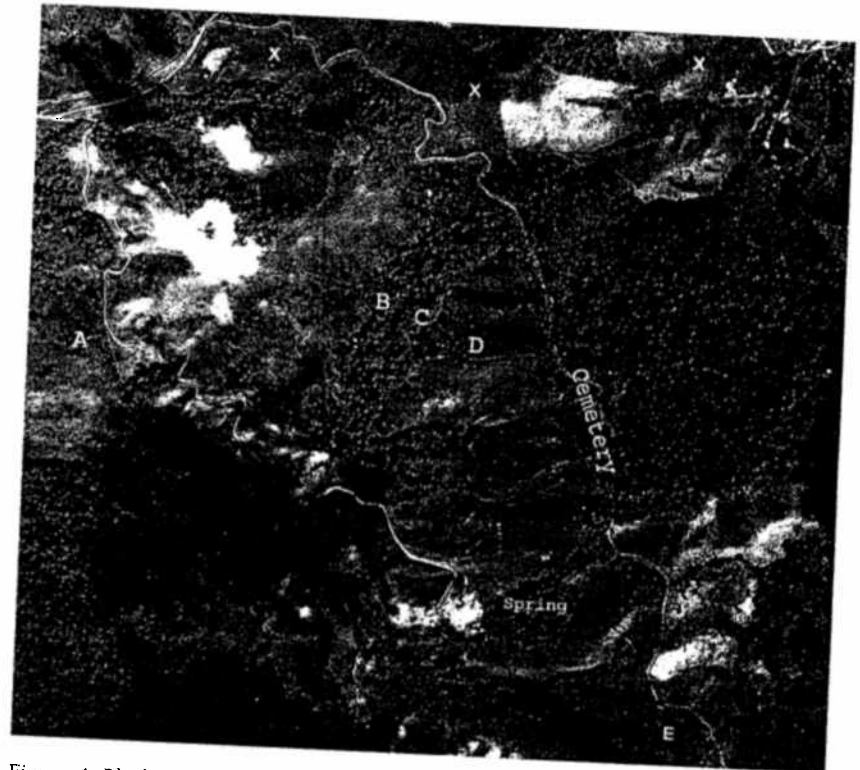

Figure 4. Black-and-white airphoto taken in 1971; horizontal distance is 2.1 km. The continental divide runs along the 2-track jeep road from the northern edge, past the Silencio "Cemetery" and past the letter "E." The earlier Arenal-phase path is at the top, marked by the series of "Xs." Three Silencio-phase paths lead south from the cemetery to the spring, and then continue to the hill marked "E" where they split into two parallel paths, and then reunite. The westward path exits the cemetery and makes an obtuse angle bend at "D" where there is a laja and mojon repository. The path splits into two and heads steeply downhill to "C" and crosses a stream, to re-emerge at "B" and head uphill to another stone repository. The path continues westward at "A" and continues downslope past the town of Tilaran to the Tovar stone source of lajas and mojones.

Tovar, just southwest of Tilaran. The straight-line distance from source to cemetery is 7 km, a long distance to carry stones that weigh on average about 25 kilos.

Thinking anthropologically, we realized that a cemetery needs a steady supply of dead bodies to stay in operation, and of mourners to do construction and post-interment rituals. The location, however, of the village, or villages, that buried their dead in this cemetery is yet unknown. It is a good possibility that it lies at the terminus of the eastward path that has been traced and confirmed for two kilometers to the east-southeast of the cemetery and no farther. Because of the trajectory of the eastward path, we believe the two most likely candidates are the sites designated G-177 and G-176 on the lakeshore (Figure 1). Both are villages that date to the same phase. There are other villages of the same phase to the north of these, which are less likely and thus not on the map. We have spent many months examining images and walking this area and doing test-pitting, during the years of 1987, 1991, 2002, 2003, and 2004, but as of yet to no avail. Certainly, the huge earthquake of 1973, which resulted in many landslides, destroyed many segments of the eastward path. Also, the road that runs down to Rio Chiquito is on top of what appears to be the most likely ridge where the ancient path may have run. If ancient and modern routes in fact share the same ridgetop, the road would have destroyed much of the path. We have trouble believing that landslides and the road completely destroyed the ancient path. Therefore, we do not understand why we have been unable to find any vestiges of the path. We do not know what concatenation of factors is causing us such frustration. And, of course, one or more villages on the western side of the cemetery, past the Tovar stone source, could have been participating in burials. We have not found a continuation of the Silencio-phase path past the Tovar source, but that does not mean it does not exist. And the fact that the decorated ceramics at the Silencio cemetery exhibit much stronger similarities to lowland communities on the Pacific side (Hoopes, 1994a) than the Caribbean side may indicate that most cemetery users came from the west. The relative amount of foot traffic on the westward and the eastward paths was approximately equal, based on the amount of erosion on comparable slopes. So it is clear to us that what we know about the Silencio-phase path network is greatly outweighed by what we do not know.

Following the peak population in this research area during the Arenal phase, the Silencio phase witnessed a decline in population to less than half of what it was, based on the numbers and sizes of sites occupied. The sites found by survey should be representative of population densities, and our excavations were in sites from all phases. We consider the survey to be the most reliable source of data for exploring demographic trends. A less reliable, but we believe not worthless, indirect proxy for demographic trends could be the relative numbers of ceramics identified of the various phases. If we assume that the total phase-diagnostic ceramics collected by the project are at least roughly proportional to ancient populations, the decline may have been even more dramatic, as in the entire research area Hoopes (1994a:205) classified 7,106 sherds to the the Arenal phase and 1,879 sherds to the Silencio phase, a decline of about 75%. This decline is in spite of the fact that more excavations were done in Silencio-phase sites than Arenal-phase sites.

The decline in sizes and numbers of sites continued in the succeeding Tilaran phase (A.D. 1300–1500), to about half of those in the Silencio phase. The ceramics show a similar decline, to only 819 (Hoopes, 1994a:205), or 44% of the previous total. All of the digital and analog remote sensing imagery has been searched for evidence of paths associated with Tilaran-phase sites, and not a single one has been found. It is likely that the ritually prescribed movement that characterized the previous two phases was eliminated during this phase. The Tilaran phase was a time of culture change, as ceramics broke from the previous painted tradition and adopted plastic decoration characteristic of peoples to the southeast. This is either a dramatic change in cultural orientation by diminishing but ongoing local residents, or it is the result of an immigration of new peoples and elimination of the former residents. Although this is a very small sample, we found only one village with burials dating to this period (Bradley, 1994), and it is important to note the lack of separation between the two. The burials were in plain pits with ceramic vessels and no stone tomb construction or any post-interment feasting or other ritual evidence. One possible other Tilaran-phase habitation site was mentioned by Hoopes (1984). Other publications exploring demographic trends in the Arenal area are by Mueller (1994) and Hoopes (1994b).

Relatively standard archaeological procedures of survey and excavation, along with volcanology, radiocarbon dating, and stratigraphy, resulted in the above-mentioned phases. It is within this chronological-spatial framework that remote sensing has made significant contributions. Below we review the kinds of remote sensing and their variable contributions to the discovery of archaeological features.

3. REMOTE SENSING INSTRUMENTATION AND IMAGERY USED TO DETECT ANCIENT FOOTPATHS

3.1. Analog Imagery

3.1.1. Color and Color Infrared

The color infrared (CIR) aerial photography is presented first here, because it was in that imagery that Sever first detected a linear anomaly that began the footpath research. Sever arranged for a NASA research aircraft overflight that took low-level high-resolution infrared photography in March 1985 (the drier season) that included the area of the Silencio cemetery and the pasture to the west. In that pasture he detected a faint but slightly redder line that indicated somewhat healthier pasture grasses, and excavations of three trenches the next day confirmed the footpath atop the ridge and that it divided into two paths down the steeper slope. Other overflights, at elevations between 1,000 and 30,000 feet above terrain, have proven very useful in detecting anomalies that turn out to be ancient footpaths, particularly when they are flown in March or April, the drier months when plants can experience slight moisture déficits.

Color aerial photography was taken during the same low-level overflight, and is of some utility in detecting linear anomalies. As it is less sensitive to variation in photosynthetic exuberance than the CIR, it has been used much less for our purposes. All of the low-elevation aerial photography is of exceptionally fine resolution, so we can detect features a few centimeters in size. For instance, we can resolve children's hopscotch chalk marks on sidewalks in the town of Tilaran, and individual rocks in Arenal-phase cemeteries that are exposed on the surface, i.e., not buried by volcanic ash or vegetation. We gave landowners copies of color and CIR aerial photography of their houses and/or their ranches, which they greatly appreciated. We did have one interesting case where a man was excited to identify his house in Tilaran in the CIR imagery, but then he noted "this is Jose Luis's pickup truck in front of my house. When was this taken?"

3.1.2. *Black-and-white Aerial Photography*

After noting how clearly the ancient paths can be detected in the CIR photography, we went back to the very inexpensive black-and-white 9"× 9"contact prints made from negatives from professional large-format cameras, which are available from the Costa Rican Instituto Geografico, and we found that we could readily detect the paths. In the areas where the paths still leave an indentation today, the black-and-white airphotos were almost as useful to us in tracing their routes as the color infrared airphotos. However, in areas where there is no present surface indentation, the color infrared airphotos were the only ones sensitive to the buried paths, because the root matrix of vegetation was different along the path from that away from the path.

When we identified a section of a 9"× 9" contact print that was of interest, we had 3"× 3" sections of the negatives enlarged to 1 m × 1 m, so we could resolve features less than a meter in diameter, and the footpaths became highly visible. In addition to the modest cost of only a few dollars, another advantage of the black-and-white photos is that large-format cameras have been flown over Costa Rica about once a decade since the 1940s, providing time-sequential coverage. Sun angle has proven to be a crucial factor in path detection, and the variation inherent in so many overflights highlights the microtopographic features on various slopes in ways a single overflight cannot. Often a path anomaly is not visible with one sun angle but highly visible with another. Another advantage of this historical aerial photography is that it helps resolve some big problems. For instance, a large dam built in the late 1970s more than doubled the surface area of Lake Arenal, flooding many areas of interest. Fortunately, pre-1980 airphotos record the area prior to that impoundment. And the huge earthquake of 1973 dislodged massive landslides that destroyed much of the Silencio-phase path to the east of the cemetery, but we have found portions of it in pre-1973 airphotos. We encourage high-tech remote sensing enthusiasts not to neglect this low-tech, inexpensive, easily available, and effective resource.

3.2. Digital Imagery

3.2.1. *Thermal Infrared Multispectral Scanner (TIMS)*

The Thermal Infrared Multispectral Scanner (TIMS) was flown in the NASA research aircraft in March 1985 at 6,250 feet, resulting in a 5-meter ground-resolution pixel over the research area. CIR photography (discussed above) was acquired simultaneously at 60% overlap for stereoscopic viewing. The six bands of the TIMS range from 8.2 to 12.2 micrometers. These bandwidths were successful in detecting linear anomalies by very subtle temperature differences, and the anomalies were later confirmed as Silencio-phase footpaths to the northwest and the southeast of the cemetery (Figure 5). The thermal response of a land surface is dependent upon complex interactions between many physical and vegetational factors. In agricultural areas and grasslands, the amount of vegetation cover, its composition, and soil moisture all influence the thermal response. Differences in forest structure present a complex range of surfaces such as the type of forest canopy, depth, and architecture. In addition, ground slope can become an important factor in the flow of radiant energy fluxes. As a result of these various factors the TIMS was able to detect various pathway locations based on thermal inertia differences.

3.2.2. *Radar*

Radar imagery was obtained at the same time TIMS data were acquired (Figure 6). Of all the imagery used for Arenal project research, radar was the farthest from the visible portion of the electromagnetic spectrum. Perhaps not surprisingly, it was also the most challenging to interpret. This L-band, 24-cm, 1.225GHYz radar system was flown aboard a NASA aircraft and gathered microwave data with four polarizations at 30- and 10-meter resolutions. The data acquisition resulted in a plethora of linear anomalies being detected in uncut tropical rainforest, in secondary regrowth, and in pastures. Following ground truthing many linear anomalies turned out to be historical and recent features, but others were not clear even after ground inspection. Only a few were ancient footpaths, verified by excavations and stratigraphic interpretations. Several filtering techniques were utilized to attempt to reduce the noise in the data, but they were unsuccessful. Part of the reason was

Figure 5. Thermal Infrared Multispectral Scanner image obtained in March 1985 of the Silencio Cemetery and the Spring. Horizontal distance shown is approximately 1.3 km. The three ancient Silencio-phase paths linking the cemetery to the spring can be seen, because of very subtle differences in thermal inertia. The large dark area northwest of the cemetery is the shadow of a cloud.

that prior to the time of data acquisition the primary antenna had been damaged, and a substitute antenna was used, generating uncalibrated data. Consequently it was difficult to reduce the data for meaningful archaeological interpretation.

3.2.3. *Landsat*

Landsat Thematic Mapper satellite imagery was obtained by NASA of the northwestern portion of Costa Rica in 1985, and it proved useful for documenting the dramatic moisture differences in the research area. That ranges from the wet tropical forest on the Caribbean side in the east to the quite dry conditions and sparse vegetation cover on the Pacific side in the west. Seasonality is highly developed in the west and almost nonexistent in the east. The areas affected by the explosive eruption in 1968 and the subsequent lava flows from the Arenal volcano that are continuing even to today (2004)

Figure 6. Radar image acquired in March 1985 including the Silencio Cemetery ("S C") and the spring ("Sp"), both in heavy tropical-rainforest vegetation. Pastures are darker. Note numerous linear anomalies, none of which turned out to be an ancient footpath. Some anomalies are fence lines while others are roads and unknown phenomena. Approximate horizontal distance is 2.5 km.

are clearly recorded, as well as the continuing gas emissions from the crater. The 30-m pixel size is not suitable for detecting the footpaths as anomalies, or the habitation sites. The only archaeological features visible in LANDSAT imagery are the large and looted Arenal-phase cemeteries. As they had been discovered by looters during the past century, and are well known to people living in the area, there is no reason to use LANDSAT to rediscover them.

3.2.4. *Ikonos*

Satellite technology has improved vastly in recent years, and four scenes of IKONOS satellite imagery were obtained recently, when cloud cover was less than 5%. IKONOS provides 1-m resolution panchromatic imagery and four multispectral bands (visible and near infrared) at 4-m resolution. The satellite has a polar, circular, sun-synchronous 681-km high orbit, and both sensors have an at-nadir swath width of 11-km. Pan-sharpening techniques were used to "fuse" the 1-m resolution high-resolution panchromatic with the 4-m multispectral imagery. The resultant high-resolution color imagery was sufficient to detect the linear anomalies created by ancient footpath use during both the Arenal and Silencio phases. Of the several available pan-sharpening techniques, our datasets were most successful when we used Brovey and Principal Component transformations.

Various band combinations, contrast enhancements, and filtering techniques were applied to the data to extract linear and curvilinear patterns. Since the data were georeferenced, features in the imagery could be located within 2-m accuracy on the ground using a GPS unit. In addition to ancient footpath segments, the data revealed erosional drainages, the location of historical-period fence lines, and a few century-old ox-cart roads, all of which were investigated and identified through ground survey, excavations, and stratigraphic analyses.

3.3. Image Analysis

The evolution of image analysis software, laptop computers, and GPS technology has revolutionized our ability to conduct field research. Originally, in the mid 1980s, we processed the data on mainframe computers in our offices and labs in the U.S., and made hard-copy outputs that we took to the field in Costa Rica. In recent years our analysis capability has become more proactive, efficient, and quick. Now we take our laptop computers to the field, which allows us to review imagery in real time, both at our field lab and literally in the field as we are walking the terrain. This ability allows us to quickly resolve questions that we incur in the field as well as determine the areas to be surveyed the next day. In addition, the image analysis software has become more user-friendly. Some of the software packages we used include ERDAS Imagine (1999), Remote View (2003), and Skyline Terra Explorer (2003).

These software packages allowed us to review both historical and recent imagery and provided the capability to monitor the land-cover/land-use changes that are occurring in the study area, threatening to destroy, or actually destroying the ancient footpaths. The Skyline software allows us to analyze the data in a virtual mode. For instance, the georeferenced remote sensing imagery was merged with topographic information and the locations of known footpath segments, cemetery areas, and excavated trenches were labeled and overlaid onto the data. In this way we were able to investigate the landscape as if we were flying over the study area in a helicopter with complete control over altitude, direction, and speed, and land at any spot with a 360-degree view of the horizon. We were also able to measure both the true and linear distance between features. Through these virtual methods, we were able to get a better understanding of the relationships between natural and cultural features upon the landscape and to become familiar with an area before beginning our ground survey. As a result of the advancements in computer hardware and software technology, all of the information associated with the footpath study can be stored, preserved, and easily shared with others.

For our objectives, to discover linear anomalies in remote sensing imagery that could be investigated and verified as ancient footpaths, the most effective means was visual inspection of color infrared aerial photographs, followed by black-and-white and true-color aerial photographs. In the digital domain, the new IKONOS satellite imagery was found to be dramatically superior to any of the other imagery. TIMS came in a distant second, with LANDSAT and radar imagery being the least useful.

4. IMPLICATIONS: INADVERTENT PATH EROSION TO MONUMENTALITY

The earliest erosional paths that we have detected connecting special places in the Arenal area date to about 500 B.C., and the phenomenon continued for almost 2 millennia, to about A.D. 1300. Societies in that area remained relatively simple, never developing into chiefdoms. In contrast, to the east of the Arenal area a series of chiefdoms developed toward the end of that time span, at about A.D. 1000. (These observations do not presume a unilinear evolutionary model, as societies can and in fact do increase and decrease in complexity, in response to a wide range of internal and external factors.) We assume that the emergent chiefs to the east of Arenal were in need of monumentality to impress people. We define monumentality as controlling labor to construct large facilities that were beyond the practical domain in nature and scale, that demonstrate centralized authority in the process of construction and in maintenance (Trigger, 1990). They needed something that, after it was built, would impress their followers as well as visitors from other polities. We suggest chiefs selected as the core of their concept of monumentality what had developed in the Arenal area centuries before, that the favored or proper way to enter a special place is by a sunken, long, straight entryway. We are not suggesting a direct and unique or exclusive relationship between inadvertent early erosional paths around Arenal and the later constructed sunken entryways. Rather, we are suggesting the kind of non-constructed sunken entryway that developed at Arenal and other areas of ancient Costa Rica became a valued cultural ideal that was later adopted by rulers seeking monumentality. Of course, a simple sunken path that developed inadvertently would not satisfy chiefly needs for monumentality, so not surprisingly chiefs, seizing that cultural ideal, constructed massive sunken entryways. In lowland areas where the gradient was slight and the alluvial sediments were fine-grained, they used earthen construction. On the sloping flanks of the volcanoes the most abundant building material is stone, and so the causeways and the facings of buildings were built of stone.

The clearest example we can offer of constructed earthen monumentality on the Atlantic plain is that of Cutris, located 52 km east of Arenal volcano. The Cutris site is a challenge to deal with in this chapter, as it has few substantive publications. Quesada (1980) was the first to mention Cutris in print, followed by Guerrero et al. (1988). Much of what we present here derives from our work with black-and-white airphotos from the Instituto

Geografico, and from a personal site visit by Sheets in 2003. Some information is gleaned from a recently written manuscript that, if/when it is accepted for publication, will be the first substantial article on the site (Vazquez et al., n.d.) Two radiating deep roadways can be seen on the map and in the airphoto (Figures 7 and 8) heading over 4 km to the northeast and the northwest from the site. Vazquez et al. (n.d.) have been able to trace the roadways farther, from at least 6.7 to as much as 9.4 km from Cutris. Each of the four roadways ends at a community smaller than Cutris, and likely dependant upon it. As Vazquez et al. (n.d.) note, this can be considered a localized interaction sphere (*"una esfera de interaccion inmediata"*). As the roadways approach Cutris center, in their last kilometer, they widen considerably, to almost the width of a football field from berm top to berm top. The original constructed depth below the surrounding terrain is unknown, but from present-day surface inspection it appears that the long roads were excavated to a depth of at least 4 m. One

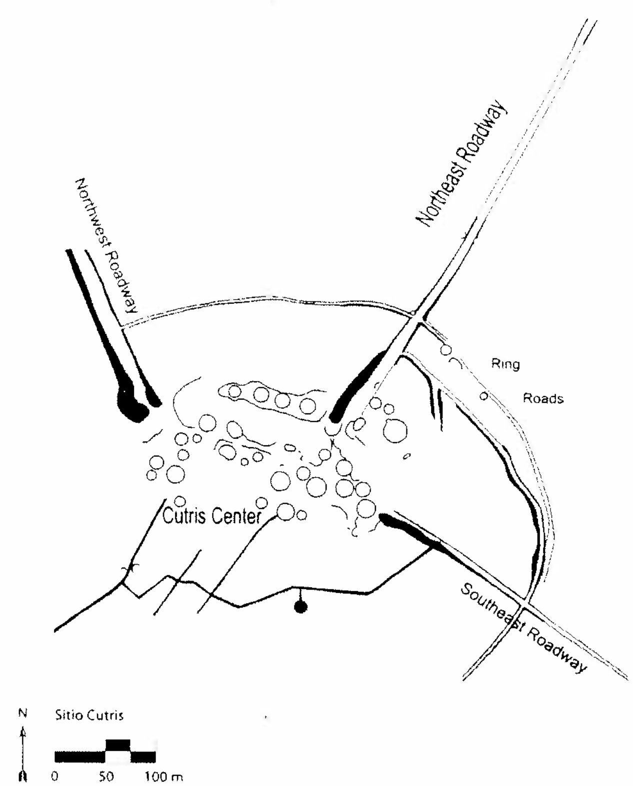

Figure 7. Map of Cutris chiefdom site, with roads radiating out of the site center. Two ring roads run around the site and connect the radii.

Figure 8. Airphoto of Cutris, site center at bottom, and radiating roads. The roads were excavated deeply into the alluvium, and broaden to about the width of a football field as they enter the site center. The Northwest and Southwest roads run for almost 4 km from the site center. The ring roads are barely visible. Someone entering the site from one of the roads would see little of the surrounding countryside for a long distance, before entering and having the view of the entire site center opening up.

wonders how water runoff was controlled, as the area receives over 3,000 mm of mean precipitation annually. And, at regular intervals of slightly more than 300 m, on top of the berms people constructed stone platforms, at least as the entryways get close to the site center (Guerrero personal communication 2003). We suggest these could be more formal versions of the small stone features/platforms on either side of the narrow path on top of the hill at Rio Piedra, about a millennium earlier. People standing on the platforms could consecrate the people in procession below, and those people below almost certainly had abandoned the single-file transit employed in the Arenal area. In addition to the long straight roadways, Vazquez et al. (n.d.) encountered what we call "ring roads" that curve and connect the main roadways. The "ring roads" are not as deep or wide as the main roadways. Vazquez et al (n.d.) also report zigzag sunken roadways that connect two of the main roadways. One can only imagine the complex processions that approached and entered the site center from the four villages, and the intercommunications on the ring and zigzag roads.

And Cutris is not the only chiefdom site east of Arenal with sunken straight entryways. The Fortuna site, 18 km east of Arenal volcano, has broad sunken roadways that are of the same scale, as they enter the site center, as those at Cutris. Unfortunately the Fortuna area has been more heavily plowed and affected by modern activities, and the roadways are not as well preserved. Stone and Balser (1965) conducted limited excavations at Fortuna.

In the rocky foothills of the volcanoes, chiefdom centers such as Guayabo de Turrialba (Aguilar, 1972; Fonseca, 1981; Murillo, 2002) built long *calzadas*, at least some of which were built of stone, to connect other centers about 4 km away. And they built impressive lowered entryways of *calzadas* and staircases to enter the site center, passing between twin large stone platforms (Figure 9). The large stone platforms have been interpreted in military-defensive ways, and considered to have functioned as "guard towers." Based on the above-mentioned discoveries, we believe that the interpretations of these features as defensive are no longer tenable. Entryways, whether *calzadas* or sunken earthen roads, that radiate out from site centers for many kilometers, to connect with other settlements, make no sense as defensive features. Roadways that connect central places with outlying settlements were constructed to

Figure 9. Entrance to Guayabo up a large stairway, past the two "Guard Towers," and then to the site center. The two towers more likely functioned in a ceremonial manner. Guayabo is in a more mountainous and rocky environment than Cutris, and subrounded river rock was used for construction. The sense of a sunken entryway is preserved.

facilitate contact rather than to hinder it, and we believe researchers should be looking into the kinds of contact that were being facilitated. The possibilities run the gamut from religious through social, economic, and others. These long-constructed features make a lot more sense as chiefs' demonstrating their mentality of monumentality, of the need to stage impressive processions and displays, the need to facilitate a variety of contacts with surrounding communities, and the need to impress their subjects and visiting dignitaries.

5. CONCLUSIONS

Native peoples have lived in what is now Costa Rica for some 12,000 years. For about 10,000 years of that time span their travel across the landscape left no trace that we have been able to detect. We believe that travel was task-specific, and thus sufficiently randomized across the countryside not to leave permanent marks. We see that result as fortunate. The environment of the tropical rainforest is sufficiently resilient to erase the footsteps of ancient inhabitants for 83% of the time they occupied Costa Rica. The cognitive structure of how they experienced their landscape changed at about 500 B.C. in the Arenal area when people separated villages from cemeteries, and began formal ritual movement between them. As they traveled the straight-as-possible route single-file across the countryside between these special places, their footprints initiated path compaction. On slopes, during heavy rainstorms, the linear compaction eroded downward. That erosion progressively entrenched paths downward, and the unused sides also followed downward. In many places the path and its sides became entrenched to a few meters below the surrounding landscape (Figure 10). We suggest here that a new ideal way of entering a cemetery developed in the last centuries of the first millennium B.C. That was to travel in a deep linear path with limited visibility, which changed dramatically as one arrived at the cemetery and it opened up to view. Thus, an unanticipated result of prescribed procession became the ideal, with no effort of construction. People created more than they initially intended by repeated passage from village to cemetery and back, literally embedding that passage into the landscape, and embedding it into social memory.

About A.D. 1000 more complex societies developed to the east of the Arenal area, and chiefs developed the mentality of monumentality. They "writ large" the proper straight entrenched entryways of simpler earlier times, in some cases with huge earthen constructions and in other cases with massive stone features. These long entryways often ran for a few kilometers, with platforms flanking them. What began a simple standard of travel between special places in earlier times, became the way elites constructed monumentality. We suggest this Costa Rican case is not unique. Rather,

Figure 10. From humble beginnings we see the seeds of monumental entryways. Ramon and his horse riding in the vestige of the Silencio-phase path, on the continental divide, southeast of the spring. While in use, the path would have been more than 3 meters below the surrounding ground surface. The four volcanic ash layers from Arenal volcano that were deposited across the landscape after the path ceased to be used have smoothed out the topography and filled-in the path depression somewhat.

elites seeking to institute monumentality are going to be more successful if they can incorporate a deeply held belief about what is proper, desired, and needed, that has centuries of authenticity. The incorporation of the simple into the monumental must have occurred many times in world prehistory.

6. ACKNOWLEDGEMENTS

It is with great gratitude that we acknowledge the support for this project provided by John Yellen and the National Science Foundation. The National Geographic Society has provided key funding at important times. NASA has been very supportive of the project research goals by assisting with personnel, equipment, software, and imagery at various times since the 1980s. We appreciate the assistance of personnel in the Museo Nacional de Costa Rica, and the Comision Nacional de Arqueologia. In particular, Ricardo Vazquez, Juan Vicente Guerrero, and Maritza Gutierrez have been especially helpful to us. During many years dedicated crews of students from the US and Costa Rican universities have done excellent fieldwork as well as technical analyses. In particular I thank Brian McKee, John Hoopes, John Bradley, Mark Chenault, and Marilynn Mueller. The local landowners in the Arenal-Tilaran have been extraordinarily gracious in allowing us to walk their properties and occasionally to excavate trenches to verify (or not) anomalies as ancient paths. We appreciate the patience of our wives, Candy Sever and Fran Sheets, for our extended absences as we chased the occasionally evanescent ancient path across the gorgeous Costa Rican landscape, and puzzled about their functions and their meanings.

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Remote Sensing in Archaeology

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Springer 2007