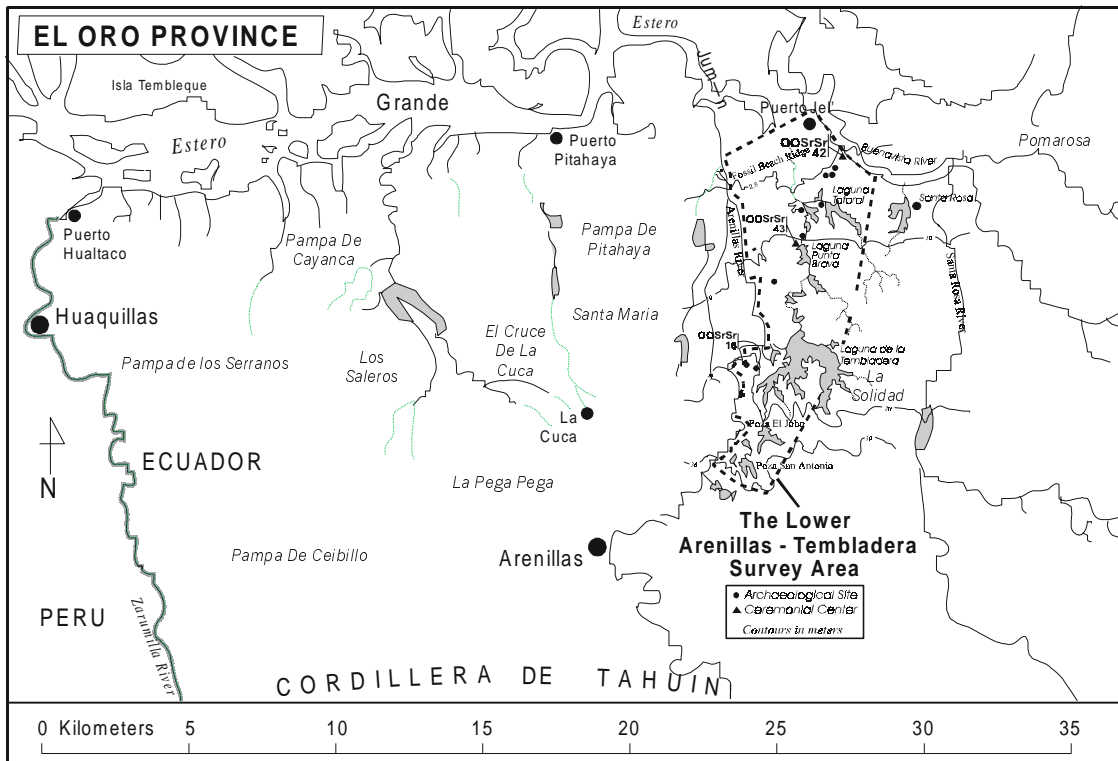


**Fig. A.** El Oro Province, showing Early Formative sites in the Lower Arenillas-Tembladera survey area



### CA+ Appendix A

While many biologists accept that maize is a domesticated form of teosinte (J. Bennetzen, E. Buckler, V. Chandler, J. Doebley, J. Dorweiler, B. Gaut, M. Freeling, S. Hake, E. Kellogg, R. S. Poethig, V. Walbot, and S. Wessler, "Genetic evidence and the origin of maize," *Latin American Antiquity* 12[2001]:84-86), arguments persist over the exact mechanism of evolutionary change (MacNeish and Eubanks 2000; M. W. Eubanks, "An interdisciplinary perspective on the origin of maize," *Latin American Antiquity* 12[2001]:91-98). In Benz's (2001) study of the Guilá Naquitz cobs, three of the four cob morphological characteristics tested distinguish true maize from teosinte. Teosinte has two rows of seeds alternating on a single stem while maize has multiple double rows of seeds on a cob (polystichous); 8 row is the most primitive grown today, but there is 12-row, 16-row, etc. Three of the Guilá Naquitz cobs do not have all four maize characteristics: one cob has three of the four and the other two cobs have two of the four. It is perhaps inaccurate to call these plants "cobs," since they do not have all necessary morphological characteristics to be called true maize at this point in their evolutionary development. These "cobs" are genetically very early and in a sense "transitional" forms evolving to true maize. All three Guilá Naquitz cobs have the *tgal* mutation - soft glumes - while teosinte has hard, stiff glumes. We may conclude that the *tgal* mutation appears early in the distribution of domestic *Zea*; exactly when is at this point unknown but apparently some time before the Guilá Naquitz cobs.

The position taken by D. Piperno ("Paleoethnobotany in the neotropics from microfossils: New insights into ancient plant use and agricultural origins in the tropical forest," *Journal of World Prehistory* 12[1998]:393-449), however, is predicated upon the existence of a domestic *Zea* with hard glumes that is more primitive than the Guilá Naquitz cobs. As Benz (2001) has pointed out, however, the glumes on all three Guilá Naquitz cobs are soft, and soft glume configuration is one of the first (of two) characteristics acquired by *Zea*, making it unlikely that pre-Guilá Naquitz cobs anywhere (much less everywhere and widespread) are hard-glume. These data suggest that domestic pre-Guilá Naquitz cobs would have had soft, not hard glumes.

Archaeological reports indicate that wild grass seed was collected at Tehuacán from the earliest levels on up (R. S. MacNeish, "Summary of the subsistence," in *Prehistory of the Tehuacan Valley*, vol. 1, *Environment and subsistence*, edited by D. Byers [Austin: University of Texas Press, 1967], pp. 290-309; Long et al. 1989; B. F. Benz and A. Long, "Prehistoric maize evolution in Tehuacan Valley," *CURRENT ANTHROPOLOGY* 41[2000]:459-65). Early maize first appears as a minority among the wild grass seeds and increases over time. However, teosinte seed at Tehuacán is almost completely absent in the midst of all the wild grass seed and the rising frequency of maize (MacNeish 1967). In Oaxaca, early Guilá Naquitz cobs have the potential to produce copious quantities of both seeds and plant macrofossils, but hard-glume teosinte is not present (K. V. Flannery, editor, *Guilá Naquitz: Archaic foraging and early agriculture in Oaxaca, Mexico* [New York: Academic Press, 1986]). Flannery states that teosinte seeds are rare in their collections and some are collected along with true maize, meaning that teosinte may have been an agricultural weed in maize fields. Modern Mexican farmers occasionally plant teosinte with maize to get cross-pollination and disease resistance.

## CA+ Appendix B

La Emerenciana gets its name from an abandoned historical port located about 200 m northeast of the prehistoric midden. A tall ceibo (*Ceiba trichistandra*) tree located in the middle of the north end of La Emerenciana is the most prominent natural feature at this locality (Staller 1994: pl. 7). The tallest ceibos on the coastal savanna are visible for distances of several kilometers and represent natural landmarks to people living in the region. They are the last remnants of what was until about 25 years ago a biologically diverse old-growth forest (L. Cañadas-Cruz, *El mapa bioclimático y ecológico del Ecuador* [Quito: Banco Central del Ecuador, 1983]). Average annual precipitation is highly variable, averaging approximately 500 mm with average annual temperatures of 22.7-27.1 °C (T. Wolf, *Geografía y geología del Ecuador* [Leipzig, 1892]; H. K. Svenson, *Vegetation of the coast of Ecuador and Peru and its relation to that of the Galapagos Islands* [Brooklyn Botanic Garden Contribution 104 (1946)]; E. N. Ferdon, "The Climates of Ecuador," in *Studies in Ecuadorian Geography* (School of American Research and Museum of New Mexico Bulletin 15[1950]:35-63; F. L. Wernstedt, *World climatic data* [Lemont, Pa.: Climatic Data Press, 1972]). The rainy season extends for about three months between the end of December and late March with a nine-month-long dry season. The region, located at 3°25" south latitude and 80° west longitude, is characterized by periodic drought and greatly influenced by the El Niño Southern Oscillation (Staller 1994, 2001).

## CA+ Appendix C

A total of six stratigraphic layers with well-defined interfaces were distinguished by color and texture (table A; see Staller 2001:127-28). These included two Valdivia occupation floors corresponding to strata 3 and 5. A sterile white sand layer (stratum 4) that corresponds to dune formation representing a brief abandonment episode separated the occupation layers. Excavations were by natural stratigraphic layers and focused upon the identification of 139 archaeological features associated with artificial mound construction, as well as post molds, pits, ritual offerings, and human burials.

**TABLE A.** *Primary Stratigraphic Layers at La Emerenciana (OOSrSr-42)*

Stratum	Depth (cm)	Horizon	Color	Description
6	0-55	A	10yr 5/3- 10yr 5/4	Brown fine silty loam, loosely consolidated in the upper levels, more dense in lower levels, with evidence of bioturbation. (fluvial deposit)
5	15-93	B	10yr 6/1- 10yr 5/1	Homogeneous gray ashy loam, loosely packed, very fine texture, fine quartz inclusions with the consistency of talc, and artifact and shell remains in the uppermost levels of the stratum. (Living Floor 2). (ethnostratigraphic)
4	36-92	C	10yr 8/3	White dune sand, finely textured very loosely consolidated, with calcium carbonate inclusions in the upper levels. (eolian deposit)
3	78-145	Bwn	7.5yr 6/4- 7.5yr 7/4	Pink quartz sand finely textured well consolidated, free of inclusions. (Living Floor 1) (ethnostratigraphic)
2	64-134	Bwk	2.5y 8/6- 2.5y 8/8	Yellow sand finely textured, loosely consolidated, with calcium carbonate small pebble inclusions (3mm-1cm). (eolian deposit)
1	97	C	5y 8/2- 5y 8/4	Olive white sand, finely textured, moderately moderately packed, with small (3mm-2cm) beach pebbles and calcium carbonate inclusions. (fluvial deposit)

Note: All soil colors are classified using the Munsell Soil Color Chart 1975 Edition. Depths are given as below datum, and indicated as minimum and maximum levels which varied in different areas of the excavations.

SOURCE: after Staller (1994:table 14).

## CA+ Appendix D

Benz (2001) has indicated on the basis of morphological analysis that when maize was initially brought into a foreign setting it initially underwent rapid genetic change reflecting human selection, after which it became relatively stable for a long period of time. K. O. Bruhns (*Ancient South America* [Cambridge: Cambridge University Press, 1994]) has also noted that modern indigenous varieties of maize in a given region of the Andes seem to be visually similar to prehistoric ones. These morphological and empirical data provide direct evidence of a phylogenetic relationship between modern Ecuadorian canguil, the maize phytoliths from carbon residues of Valdivia pots from La Emerenciana, and the later highland maize from Pirincay.

## CA+ Appendix E

It is critical to establish a site-relevant isotopic baseline for interpreting human skeletal data. While most plants follow either the C<sub>3</sub> or the C<sub>4</sub> photosynthetic pathway and have similar carbon isotope ratios in most ecological settings, succulent plants such as the *Cereus* spp. found at La Emerenciana today utilize the alternative CAM (crassulacean acid metabolism) photosynthetic pathway, which also results in enriched carbon isotope ratios (M. H. O'Leary, "Carbon isotopes in photosynthesis," *BioScience* 38[1998]:328-36). CAM plants are unlikely, though, to have been major sources of dietary protein, whether consumed directly or indirectly through herbivorous faunal intermediaries. In addition, none of the modern wild fauna from this region tested by van der Merwe, Lee-Thorp, and Raymond (1993) had carbon isotope ratios which demonstrated the consumption of C<sub>4</sub> or CAM plants.

Nitrogen isotope ratios are influenced by rainfall and other factors (S. H. Ambrose, "Effects of diet, climate, and physiology on nitrogen isotope abundances in terrestrial foodwebs," *Journal of Archaeological Science* 18[1991]:293-317), and both carbon and nitrogen isotope ratios vary considerably among marine organisms (M. J. Schoeninger and M. J. DeNiro, "Nitrogen and carbon isotopic composition of bone collagen from marine and terrestrial animal," *Geochimica et Cosmochimica Acta* 48[1984]:625-39). Analyses of faunal remains provide a good estimate both of the animals themselves and of the plants they consume. This is particularly important because in many areas, while maize may be the only C<sub>4</sub> plant cultivated and consumed directly by humans, other C<sub>4</sub> grasses may exist and be consumed by grazing herbivores, which pass on an enriched isotopic signature to their human consumers.

Empirical data for large mammals combined with experimental data for rats and mice indicate that bone collagen is enriched about + 5% relative to diet, although this value is affected by the proportion of protein in the total diet and differences in  $\delta^{13}\text{C}$  values between protein and energy sources (M. J. DeNiro and S. Epstein, "Influence of diet on the distribution of nitrogen isotopes in animals," *Geochimica et Cosmochimica Acta* 45[1981]:341-51; N. J. van der Merwe, "Natural variation in C13 concentration and its effect on environmental reconstruction using C12/C13 ratios in animal bones," in *The chemistry of prehistoric human bone*, edited by T. D. Price [Cambridge: Cambridge University Press, 1989], pp. 105-25; S. H. Ambrose and L. Norr, "Experimental evidence for the relationship of the carbon isotope ratios of whole diet and dietary protein to those of bone

collagen and carbonate," in *Prehistoric human bone: Archaeology at the molecular level*, edited by J. B. Lambert and G. Grupe [New York: Springer-Verlag, 1993], pp. 1-37; L. L. Tieszen and T. Fagre, "Effect of diet quality and composition on the isotopic composition of respiratory CO<sub>2</sub>, bone collagen, bioapatite, and soft tissues," in *Prehistoric human bone: Archaeology at the molecular level*, edited by J. B. Lambert and G. Grupe [New York: Springer-Verlag, 1993], pp. 121-55. Ambrose and Norr's experimental data on rats also convincingly demonstrate that bone apatite is enriched about + 9.5% relative to the whole diet, regardless of the mixture or isotopic composition of the foods consumed, although empirical data for larger herbivores suggest that the diet-apatite spacing is about + 12%. Information from ethnohistoric and other sources, along with isotopic data for relevant food resources, may ultimately be used to propose specific dietary mixing models to account for human bone isotope ratios (J. D. C. Little and E. A. Little, "Analysing prehistoric diets by linear programming," *Journal of Archaeological Science* 24[1997]:741-47).

## CA+ Appendix F

To extract collagen, whole bone was demineralized in 2% hydrochloric acid, base-soluble contaminants were removed using 0.1 M sodium hydroxide, and fatty components were dissolved in a 2 : 1 : 0.8 mixture of methanol, chloroform, and water. Freeze-dried collagen pseudomorphs weighing less than 1 mg were analyzed using a Carlo Erba CHN analyzer coupled with a VG Prism II stable isotope ratio mass spectrometer. Analytical precision is  $\pm 0.1\%$  for  $\delta^{13}\text{C}$  and  $\pm 0.2\%$  for  $\delta^{15}\text{N}$  (see S. H. Ambrose, "Preparation and characterization of bone and tooth collagen for isotopic analysis," *Journal of Archaeological Science* 17[1990]:431-51).

Enamel and bone apatite samples were carefully cleaned and powdered using a Spex freezer mill, and approximately 100 mg of powder were immersed in 2% sodium hypochlorite for 24-72 hours to dissolve organic components. Nonbiogenic carbonates were removed in 1.0 M acetic acid for 24 hours. Purified CO<sub>2</sub> was obtained by cryogenic distillation, and the gas sample was introduced to the mass spectrometer through a manifold system. Reliable results have been obtained using similar procedures on samples even of Plio Pleistocene age (J. A. Lee-Thorp, "Preservation of biogenic carbon isotopic signals in Plio Pleistocene bone and tooth mineral," in *Biogeochemical approaches to paleodietary analysis*, edited by S. H. Ambrose and M. A. Katzenberg [New York: Plenum, 2000], pp. 891-16).

The carbon isotope ratios in pottery residues were determined by Beta Analytic as part of the standard correction procedure used in radiocarbon dating. Solid samples weighing less than 100 mg each were pretreated with an acid wash.