CONSERVATION AND INTEGRATION AT EL PILAR:
The Field Report for 1999

INTRODUCTION TO EL PILAR 1999

The BRASS/El Pilar Program is more than an archaeological research program. Building on the long-term study of Maya settlement, the program's look at the community center of El Pilar in 1993 signaled a new focus. To consider the monuments of El Pilar required a fresh approach. The archaeologist wished for preservation, the ecologist wished for conservation, and the Mesoamericanist saw that the heritage values. El Pilar provides an opportunity to address it all.

The collective expectations for El Pilar have evolved from a simple wish to look at all of El Pilar. A major Maya site demands government protection and investment in community participation. Building from the archeological research, we have gathered in a terrific group of partners for the integrated conservation enterprise of El Pilar. Together, we are designing a model and the steady successes are pointing the team to the right track.

The year 1999 marked great Strides in the goals of the El Pilar Program. The development of the reserve now includes institutionalized relationships among different parts: the government managers, the community stakeholders, and the research scientists. This institutional threshold was accomplished by remarkable teamwork among a consortium of partners --- locally, regionally, and around the globe.

Deliberate and measured paces have remarkably transformed the conceptual thesis for El Pilar into a Structured plan with a defined approach for implementation. Working with *Help for Progress* has made Amigos de El Pilar (AdEP) a truly Strong community group with a collective voice and defined goals.

Strategic development has moved El Pilar forward because of visionary representation by Anselmo Casteñeda and the careful planning by Help for Progress' director Elias Awe. Together they crafted a small grant with the US Agency for International Development that leveraged support from Canada Fund to forge cross-border community ties in the Maya forest. We have also coordinated the development of the Masewal Forest Garden and the new comfort stations at El Pilar in collaboration with Help for Progress and the British High Commission. In addition, the Protected Area Technical Evaluation Team worked with the Draft Management Plan for El Pilar, revising and creating a comprehensive plan for implementation at El Pilar.

At El Pilar, we have cast our image. No exposed temple-like the Castillo at Chichen for El Pilar; The Tzunu'un Maya house and forest garden is open to the public. This signature of the human component is not lost on the international public. This year Fodor's , which The New Yorker calls the premier travel companion, says:

> …… At El Pilar, the emphasis is on domestic architecture-reconStructing houses, replanting a garden with crops used by the ancient Maya, and generally creating a sense that people actually lived here. …[W]ell-marked trails take you around the site. Because the Structures have not been Stripped of vegetation, you may feel like you're walking through a series of shady orchards …..

It has been exciting to witness the transformation of the house site at Tzunu'un from housemounds to an excavation, to a destination. The architectural features we have exposed

over the past several years have helped to envision the result. We carefully collected artifacts from the Structural remains and ~~we~~ meticulously drew up detailed plans of the site before we could approach the presentation.

This year was the push to share our findings with the greater public locally, regionally, and internationally. While stabilizing the final parts of the walls and floors of the main building, we constructed thatch Structures over two excavated wall foundations. We knew that the buildings of Tzunu'un were large, after all it was one of the grandest residential groups recorded in the surveys. Yet, when we constructed the pole-and-thatch buildings over them, it changed the view. Then, when we took off the old provisional protective roof of the range Structure, the whole area took on a new aspect. Impressive, compelling, real.

A visit to the site reveals the success of our seasons of labor. The house Structures are comfortably situated within the flourishing forest garden, inviting discovery on the El Pilar trails. El Pilar can be a model for a new way to explore the past.

Aims of the season

Mapping

The El Pilar Archaeological Mapping Project focused on the survey coordination and development. The main objective was to verify the El Pilar site grid and transform the local grid into the UTM (Universal Transverse Macerator) grid system used by the Land Information Center of Belize. This effort involved the use of the full-station transit in the terreStrial survey of control points and the Strategic use of using GPS (Global Positioning System) to adjust the references in the old grid to UTM. The use of the UTM system at El Pilar will make the data collection, inventories and infraStructure planning part of a Geographic Information System (GIS), effectively part of the system developed and used in Belize. The data we gather for El Pilar can readily be incorporated into the larger GIS systems, including the UCSB Maya Forest GIS. The UCSB Maya Forest GIS has the potential to compile and manage Maya archaeological data from the more general center locations, to the most specific excavation data.

Tzunu'un: The Maya House

The mayor objective of 1999 field season was to complete the first stage of investigations at Tzunu'un and prepare it for presentation to the general public. The archaeological investigation incorporated confirming the method of access from plaza into Str. 1, clarifying the construction chronology and building sequences of this residential range building. In addition, the examination of Str. 2 verified its classification as a temple or shrine by completing examination of looter's trench. The superStructure remains were detailed, and evidence of construction developments identified. The complex excavation data suggest that the area was under a final renovation at the time of abandonment.

In order to present the plaza group in an interpretable manner, understandable to the general public, experimental procedures from 1998 were evaluated and incorporated into the 1999 consolidations. To increase the ease of interpretation by the average visitor, two of the smaller Structures were covered with roofs in traditional Maya style. The third Structure was exposed to view, consolidated in the open, in order to display to the general public the variety of remains from which archaeologists draw their conclusions.

Forest Garden

Work at the forest garden continued with the collaboration of AdEP and the caretakers at El Pilar. We have monitored growth and development in the forest garden at Tzunu'un and learned from the Caretaker House garden. In addition, links with Heriberto Cocom's new Masewal Forest Garden Trail promise to create new links to traditional farming methods.

Some of the issues at the forest garden concern planning. Light and shade clearly affects the success or failure of some growth. We conducted an examination of the forest garden floor with respect to the amount of sunlight reaching through the canopy. This will assist in planning future plantings. We also developed a first draft of a Tzunu'un Forest Garden Trail that features common forest trees and herbs. This will soon be assembled into a resource for El Pilar.

Community Participation

An ongoing and important aspect of the BRASS/El Pilar Program is the work with the community. The focus of the 1999 field season was to increase the awareness of different Maya tour destinations to inspire feedback on community goals for El Pilar Archaeological Reserve for Maya Flora and Fauna (EPAR) preservation and display. We also worked with Help for Progress in planning and developing the linkages that will fortify the community involvement in El Pilar.

Summary

This report documents the integrated conservation efforts that we envision for El Pilar. Our accomplishments and experience are at the foundation of a new model for conservation in the Maya forest.

THE EL PILAR ARCHAEOLOGICAL MAPPING PROJECT

The spatial data collected and recorded for El Pilar are compiled from a variety of sources: BRASS/El Pilar Program, interdisciplinary research data from ecology, agriculture, landscape-architecture, etc., government, universities, and other public domain arenas. These data are destined for integration in the UCSB Maya Forest GIS and are the basis of the El Pilar Archaeological Mapping Project, headed by William Poe of Sonoma State University, California. The data are generally organized into 1) the El Pilar Archaeological Reserve (EPAR) area and 2) the archaeological surveys and excavations.

The essential bases of the mapping in BRASS / El Pilar Program are:

- the development of a local control points network at El Pilar between 1984 and 1993 to locate the survey and excavations areas,
- the establishment of boundary benchmarks by Cayo DiStrict Lands and Survey in definition of the El Pilar Archaeological Reserve (EPAR) in 1995,
- the initiation of the El Pilar Archaeological Mapping Project with W. Poe of Sonoma State University in 1997,
- the coordination of a UCSB Maya Forest Geographic Information System (GIS) in conjunction with the Geography Department, University of California, Santa Barbara in 1998.

The Reference Network

A local control point network was established in 1993 around the civic center El Pilar and has been used for all mapping exercises at the site. Independent research operations proceed on a local grid network linked to control points within the site. The control point network serves as the central reference. In 1995, a controlled survey of the EPAR reserve boundaries was executed and provided a basis for linking the local control points at El Pilar and the international Universal Tranverse Mercator (UTM) grid system. The 1999 season was designed to unify the El Pilar mapping data onto one comprehensive system. This involved transforming the local control point network to the UTM network.

The Local Control Point Network

The local control point network is based on the Geodetic Elevation Marker E10 located in the site. The coordinates of E10 were set to 0, 0, 232 m Mean Sea Level (MSL). In 1993, the network was oriented by magnetic north as the bearing 0°. Control points at El Pilar were set up step by

step over the years, by different surveyors, following the site clearing and excavations. The development of the composite control point network across the 40-hectares of site core was individual and resulted in a mosaic with accumulated survey errors over the years of accretion. The whole network had not been adjusted between surveyors and consequently there would be some compromise expected in the reliability of the network as a whole. Consequently, a critical objective of the 1999 season was to regularize the local El Pilar control point network and unite it with the EPAR boundary survey by transforming the local grid to the UTM grid. The objective was to firmly establish critical ground controls for the basic research data and facilitate the data integration into the GIS.

The UTM Grid

In order to link the El Pilar site to a world projection system, the local network had to be transformed to universal system. The EPAR location had been defined based on one permanent Belizean reference point: SBM1. From this UTM grid benchmark, a survey line was extended to the E c. 2.1 km to the SE corner of the EPAR, from there N c. 2.9 km to the NE corner, and from there WNW to the Belize border.

Our interpretation of the Statutory InStrument (No. 54 of 1998) gives the established physical boundary coordinates of the EPAR as follows:

From the western border of Belize to:

	Northing	**Easting**
SBM1	1907180 m	271933 m
South East corner	1907180 m	274023 m
North East corner	1910034 m	274023 m

(UTM, Zone 16, Datum NAD27 Central America)
Bearing 279 °08'15" from the North East corner to the western border of Belize

To confirm the location of the EPAR trapezoid and to develop the linkage of the EPAR boundaries to the local El Pilar control point network, a GPS method was employed based on the single reference benchmark SBM1. While the GPS is the best Strategy, the Maya forest canopy presented difficulties.

Boundary and Corner Marker Survey

The monuments established to mark the physical boundary of EPAR were occupied using a rapid static GPS survey technique. This required walking the length of the boundary and locating each of the existing benchmarks. Each benchmark was then occupied with the GPS to establish the coordinates. These data were collected under different conditions and different methods. All the data were differentially corrected in the lab. The GPS data were compared with the legal description in the Statutory InStrument.

Mapping Assumptions

The legal description of the El Pilar Archaeological Reserve for Maya Flora and Fauna defines the UTM coordinates of the South Boundary Marker, SBM1, as 907180N / 271933 E as determined by the Cayo Survey Department traverse and a solar observation on 24 February 1995. The coordinates of SBM1 are only available to the closest meter and the elevation of SBM1 is not available.

Point E10 is a bronze marker set in a concrete base. The medallion is inscribed “Interamerican Geodetic Survey 1962”. The horizontal location of E10 is not available. Site records indicate that Field notes of the MiniStry of Natural Resources, Belize, define the elevation (MSL) of E10 as 231.77 m. The horizontal coordinates of SBM1 and the vertical coordinate of E10 are the assumed truths of the El Pilar Archaeological Mapping Project. Program Geomag determined the site magnetic declination at that date as 2° 44.7'. This program file is available to the public

from the WWW server of the World Data Center at
http://www.ngdc.noaa.gov/seg/potfld/geomag.html

Base Station Reference Position
The base station position was a monument placed by A. Girardin on the northeast corner of the cement platform that supports the water tank at the caretaker's cottage and is referred to as EPB1. The 1998 base station position had been a temporary location, with the base station antenna mast attached to a PVC pipe on the western side of the water tank.

The base station reference position was determined by placing the base station at the known station of SBM1 (1907180 N / 271933 E) and recording 1243 positions at 5-second intervals with the rover at the base station monument. This resulted in the following GPS determination of the base station reference position. (26 May 1999)

UTM Zone 16 North, NAD27 (Central America)				
Point	**Northing**	**Easting**	**MSL[1]**	**HAE[2]**
EPB1	1908065.635	271993.460	245.145	253.659

TerreStrial Data
A total station survey of the El Pilar local control point network was surveyed in the main plaza of El Pilar: Plazas Axcanan, Copal, Duende, Faisan, Ixim, Lec and Tzunu'un. The total station survey occupied monuments at the following twenty-eight established local control points: A2, A3, A5, A6, A9, BL_BM, C1, C5, C6, C7, C8, E10, F1, I3, L1, MB, NB, N1, N2, N4, N5, N7, N10, N11, N14, TN5, TN8, TN10. In order to provide appropriate backsights for future mapping work, the total station team established new monuments in Plaza Faisan, F2, and in Plaza Lec, L2. We also established a monument, EPB1, on the platform at the water tower next to the caretakers' cottage. This point is used as the principal location of the GPS base station.

Thirty temporary stations were occupied as needed during the course of the survey. In addition, stations T1 through T26 were established where lines of sight between control points were lacking. Stations POS1 and POS2 were established as offsets to point E10 to facilitate the location of E10 through GPS survey. Point E10 is overshadowed by trees and while GPS data was recorded on the position, it was not to the desired degree of precision (Appendix #). POS1 and POS2 were located in positions of clear sky and their relationship to E10 was defined by the total station. Similarly, L1 Offset was used as a GPS station because of the difficulty of occupying L1. Stations POS3 through POS5 were used in surveying a transect from E10 to EPB1 to determine the elevation difference between E10 and EPB1.
Satellite Data
A Trimble 4000SE GIS Surveyor was used as the GPS base station. Trimble 12-channel GPS Pathfinder Pro XL receivers with TDC1 Dataloggers were used as rovers. The receivers were set to record carrier data at five-second intervals synchronized with the base station. Data was gathered in static occupations at control points and temporary points where good reception was possible.

Differential Correction
These data were processed by the program GeoGeniusÙ by Spectra Precision Terrasat GmbH, Hoehenkirchen, Germany. This program is designed to integrate terreStrial and satellite data. The program processed the carrier data and produced the results on the baseline measurements in Table 1 below.

[1] Mean Sea Level
[2] Height Above Elipsoid

In Table 1 the columns headed *Rec 1* and *Rec 2* identify the two points being simultaneously occupied by two receivers. These are receivers that were recording GPS data simultaneously. Since two rovers were sometimes used, the baseline computed may be between two rovers or between a rover and the base station. The column labeled *Epochs* indicates the number of common epochs of data, at five-second intervals that exist between the two receivers. This is the number of measurements that will contribute to the average distance calculated between the two receivers. This distance is expressed in meters in the earth-centered earth-fixed WGS84 coordinate system and is recorded in the columns labeled *d X*, *d Y* and *d Z*. The columns labeled *s X, s Y and s Z* are the standard deviation of the measurements for each axis and are expressed in millimeters. The column labeled *Solutions* indicates whether on not the program has been able to fix the best solution within the statistical parameters specified[3]. The *L1* indicates that it is a single-frequency solution. The column labeled *2dRMS* records two times the root mean square deviation from the averages in millimeters. In a normally diStributed data set 95% of the data will lie between -2dRMS and +2dRMS of the average. The full report generated by GeoGenius is appended.

The twenty baselines processed to a fixed solution have a 2dRMS range of 14.6 mm to 40.2 mm with an average of 28.8 mm. This provides sufficient precision to orient the control point network.

TABLE 1: Summary of GPS baseline data

Rec 1	Rec 2	d X	s X	d Y	s Y	d Z	s Z	Epochs	Solutions	2dRMS
C1	EPB1	130.51	0.5	-177.264	1.3	-552.905	0.8	633	Fixed L1	29.00
C5	EPB1	195.701	0.3	-134.439	0.8	-431.09	0.4	1441	Fixed L1	23.80
C6	C1	61.111	0.7	13.744	2.2	28.394	1.1	423	Fixed L1	28.80
C6	EPB1	191.618	0.6	-163.519	1.9	-524.522	0.7	1187	Fixed L1	37.40
EPB1	E10	-11.926	0.7	88.049	1.4	241.242	0.5	725	Fixed L1	34.80
EPB1	F1	-183.124	0.4	219.371	0.9	654.812	0.3	1309	Fixed L1	25.20
EPB1	F2	-219.499	60.4	222.178	29.7	660.861	10	797	Float L1	49.40
EPB1	L1Offset	-231.377	0.6	271.321	1.5	825.655	0.7	1032	Fixed L1	33.60
EPB1	L2	-266.483	0.4	267.292	1.2	814.054	0.6	728	Fixed L1	32.40
EPB1	N1	-193.861	0.6	205.284	1	618.305	0.4	822	Fixed L1	27.00
EPB1	N2	-145.721	1	216.795	2	647.302	0.8	708	Fixed L1	34.00
EPB1	SBM1	-46.852	0.5	-282.612	1.2	-840.452	0.4	1242	Fixed L1	34.80
F2	L2	-45.855	1.9	44.619	3.4	152.957	1.2	583	Fixed L1	25.80
N1	F1	10.751	1.6	14.11	2.5	36.501	0.7	516	Fixed L1	37.00
N2	F1	-37.158	2.5	2.65	6.3	7.441	0.9	708	Fixed L1	25.60
POS1	EPB1	-6.266	0.4	-80.472	1.3	-214.567	0.7	595	Fixed L1	29.40
POS1	TN10	-1.94	0.7	46.328	2.3	154.702	1	486	Fixed L1	40.20
POS2	EPB1	30.271	0.2	-82.438	0.8	-222.204	0.3	540	Fixed L1	16.60
POS2	TN10	35.025	41.4	44.25	15.9	146.967	11.6	254	Float L1	17.20
POS2	TN5	51.342	0.6	43.638	2	147.557	0.7	70	Fixed L1	14.60
SBM1	E10	34.996	5.1	370.613	4.2	1081.653	2	725	Float L1	24.00
TN10	EPB1	-4.32	0.3	-126.796	1	-369.268	0.4	750	Fixed L1	21.60
TN5	EPB1	-21.074	0.3	-126.085	0.9	-369.76	0.4	620	Fixed L1	20.20

[3] Fisher test reliability of 99.99%, Chi-square test 95% minimum probability

Network Adjustment: The survey network is designed and measured in such a way that more elements than are geometrically necessary are observed to compute the coordinates of the network points. The triangulation geometry of the network itself provides some of the redundancy. Other redundancy is provided by the duplication of angle and distance measurement. There is some redundancy in the GPS baselines as well since there were times when three receivers were recording data simultaneously. The network adjustment component of GeoGenius computes coordinates that are optimized by the method of least squares.

If the coordinates of certain points in the network are defined as fixed then the adjustment is said to be biased. If no points are fixed then the adjustment is said to be free. A free adjustment of a network tests the internal integrity of the network. The integrity of the terreStrial data was first tested by a free adjustment. This led to the identification and correction of a few recording errors. Following this a biased adjustment was performed with the following input data.

1. The twenty fixed GPS baselines computed by GeoGenius.
2. The corrected terreStrial data from the June 1999 survey.

Two points were defined as fixed control points with the fixed coordinates entered in the WGS84 datum. The elevation of E10 was fixed at 226.979 m. HAE. This corresponds to an elevation of 231.77 m. MSL. The Latitude and Longitude of SBM was set at N17° 14' 24.40853", W89° 08' 41.61782". This corresponds to UTM coordinates of N 1907383.492 E 271939.072. This location is the WGS84 datum equivalent of the NAD27 (Central America) coordinates of N 1907180 E 271933 as per Cayo Lands and Survey Office.

The program was set to perform a Tau test following adjustment. The Tau test is a statistical procedure used to identify GPS and total station baselines that are questionable. The Tau test GPS parameters were set to flag any baseline with an error offset greater than 5.0 mm + 0.5 ppm. The parameters for the total station were set to mark any line with an distance error offset greater than 2.0 mm + 3.0 ppm and a vertical and horizontal angular error offset of 0.3 mgon[4]. The significance level was set at 1%. The significance is the probability that the test will not mark a baseline that fails the accuracy criteria. These parameters are typical and were the default parameters suggested by the program. One GPS baseline was marked by the Tau test, E10 - EPB1. Two total station lines were marked, C5 - T15 and T13 - T14. In both total station cases the vertical angle is rather steep and in both cases it is the vertical measure which has generated the error. These bad baselines are inconsequential in the total survey since the positions dependent upon them are well fixed from other lines.

Conversion to UTM Grid: GeoGenius reports the adjusted positions in latitude and longitude in the WGS84 datum. These data were reformatted and imported into Pathfinder Office as waypoints. The coordinate system was then changed in Pathfinder Office to UTM 16 N NAD27 (Central America) and control point features were created at each of the waypoints. These features in turn were exported as text files for the table below and as shape files for use in ArcView.

[4] Milligrad. 0.3 mgon is the equivalent of 0.00027º or approximately 1 sec of angle.

UTM Zone 16 North, NAD27 (Central America)				
Point	**Northing**	**Easting**	**MSL**	**HAE**
A2	1908504.347	271772.522	240.604	249.096
A3	1908472.154	271786.977	245.352	253.845
A5	1908452.168	271754.885	238.981	247.475
A6	1908446.633	271830.547	244.903	253.398
A9	1908435.698	271774.288	244.854	253.349
BL_BM	1908693.036	271868.174	235.408	243.891
C1	1908648.311	271871.869	237.379	245.864
C5	1908520.156	271804.721	241.232	249.723
C6	1908617.887	271810.241	241.070	249.556
C7	1908691.239	271845.956	235.512	243.995
C8	1908700.476	271843.844	235.196	243.678
E10	1908322.443	271986.218	231.770	240.272
EPB1	1908065.635	271993.460	245.145	253.659
F1	1908759.040	271821.115	226.563	235.042
F2	1908766.515	271783.438	225.048	233.527
I3	1908853.584	271817.643	239.120	247.595
K1	1908933.110	271765.046	226.795	235.265
L2	1908926.418	271740.111	226.873	235.344
MB	1908552.696	271828.868	241.450	249.940
N1	1908720.080	271809.795	229.121	237.602
N10	1908788.022	271812.550	226.610	235.088
N11	1908805.894	271809.339	230.176	238.653
N14	1908893.834	271808.730	239.576	248.049
N2	1908750.467	271858.342	227.366	235.846
N4	1908843.565	271756.846	228.094	236.569
N5	1908884.695	271746.084	228.856	237.329
N7	1908910.465	271800.938	230.714	239.186
NB	1908550.048	271784.450	241.379	249.869
SBM1	1907180.000	271933.000	264.501	273.059
TN10	1908456.028	272004.248	233.076	241.571
TN5	1908455.989	272020.789	233.879	242.374
TN8	1908446.157	272044.573	233.570	242.066

Comparison with previous El Pilar grid coordinates

In order to compare how closely the geometry of the 1999 control point survey matched the results of previous determinations of the control point coordinates, the *Create Local Site* feature of Pathfinder Office was used. The geometry of the control points in the UTM coordinate system was compared with that of the same control points in the El Pilar grid system. The program uses a least squares method to minimize the differences in the two coordinate systems and then produces a set of transformation parameters that can be used to transform the UTM coordinate positions to the El Pilar coordinate system. The program also reports the two-dimensional and the three-dimensional residuals from the least squares procedure. The residuals reported for the control points in the two coordinate systems are listed in the following table. The table is sorted in order from the highest residual to the lowest. High residuals identify outliers in the original survey.

Point	2D residual, meters	3D residual, meters
E10	0.189	0.399
TN5	0.182	0.374
TN8	0.162	0.315
N4	0.129	0.208
L1	0.127	0.163
I3	0.112	0.112
N5	0.098	0.174
A2	0.093	0.094
N7	0.085	0.089
N11	0.083	0.083
N14	0.066	0.069
N10	0.065	0.080
A8	0.055	0.111
N1	0.053	0.053
A5	0.048	0.094
F1	0.044	0.053
N2	0.030	0.198
A6	0.029	0.079
C8	0.026	0.134
C5	0.026	0.077
NB	0.024	0.026
C6	0.021	0.103
MB	0.021	0.103
BL_BM	0.020	0.198
C1	0.012	0.182
A3	0.005	0.117

The lower part of the table identifies a number of points with relatively small residuals. It is to be noted that these points lie in or adjacent to the contiguous plazas Copal, Duende and Faisan. In this area the geometry of the network of control points is Strong. Each control point is typically in sight of two or more other control points. When a least squares analysis is performed using only the points from A3 through N2 in the table, the two-dimensional residuals drop to a range of 0.005 to 0.018 m and the three-dimensional residuals drop to a range of 0.015 to 0.076. These relatively low residuals between the previous surveys and the 1999 survey demonstrate that the control points in this series were well located with reference to each other.

At the upper end of the table are Strikingly large residuals associated with E10, TN5 and TN8. Since E10 was defined as the origin of the El Pilar grid system, it may seem Strange to find such a high error associated with the point. However, it must be remembered that the analytic program is not aware of the special status of E10 and is only testing the fit between the two sets of survey coordinates. By this analysis E10 is an outlier. This implies that early in the transect from E10 to the core of the site there was an error of some magnitude. Except for making E10 an outlier, this error had no impact on the survey of the series of plazas since there was no need to return to E10 as an initial position. However, the survey of Tzunu'un not only originated at E10, but also used VC10 as a backsight from E10. This position was not resurveyed in 1999 because the *brecha* had become overgrown. However, the April 1998 GPS survey had noted errors in the El Pilar grid coordinates of VC1.

The *Create local site* function in Pathfinder Office was then used to apply the plane transformation parameters that it had computed to the UTM coordinates computed from the 1999 integrated survey. This permits a point by point comparison between the original El Pilar coordinates and the results of the 1999 survey. El Pilar coordinate values were subtracted from the 1999 coordinates. Thus positive values indicate that the 1999 survey placed the control points further north or east than had the original survey. These data are most easily understood when displayed in chart form. The chart divides the data into series based upon the notation of the El Pilar control point system and on proximity of the positions. The C series together with points MB and NB on Plaza Copal and point BL_BM on the edge of Plaza Duende form the tightest grouping. The A series is also reasonably tightly grouped, with the deviations close to 5 cm at a maximum. The N series is not so tightly grouped with the deviations typically in the 5 to 10 cm range. The TN series, at the left side of the chart is displaced considerably in easting, as is E10 on the far right of the chart.

These data explain why the residuals were so high in the attempt to fit the El Pilar grid to the April 1998 GPS survey. The control points occupied by the GPS receiver in that effort were C1, C5, E10, TN5, VC1 and SBM1.

Mapping Project Summary

Given the basic assumptions of mapping at El Pilar, the horizontal coordinates of SBM1 and the elevation of E10, the UTM grid coordinates for the control points listed above are considered definitive. These control points are fixed within the UTM grid system and form the foundation for all mapping at El Pilar. Furthermore, the identification of the outliers in local site coordinate system will permit the incorporation of much of the previous survey data into the UTM system.

ARCHAEOLOGY RESEARCH

TZUNU'UN – PROTECTOR OF FLOWERS AND GARDENS

The plaza group *Tzunu'un*, "hummingbird" in Yucatec Mayan, is numbered as 272-025 in the BRASS survey. The group consists of five main Structures situated on a 30 by 40 meter plaza area. This residential group is located southeast of El Pilar on a platform raised approximately one meter from the surrounding topography to incorporate the Structures. The main Structure, Str. 1, located to the south and built on a raised terrace platform. It is an imposing building, constructed with limestone walls still enclosing the range of rooms. On the east of the group is Str. 2, a pyramidal Structure of the "eastern shrine" plan, first recognized at Tikal. The other three Structures appear as foundation braces for perishable superStructures: Str. 3 has a plaster floor within the wall perimeter, Str. 4 has a marl floor inside a rough foundation, and Str. 5 has a defined wall surrounding a prepared subfloor. The 1999 season was designed to bring these house Structures to life and opening the area to public view.

Excavation Methodology

The procedures at Tzunu'un for the field season of 1999 followed those of previous years work of the BRASS/El Pilar Program. We have consistently developed and standardized our data collection for comparability from year to year. Excavations were conducted by Stratigraphic levels, using a modified version of the Harris matrix adapted for the program. Collections were all screened through mesh to maintain volumetric standards for both contexts of fill and middens. Half-inch screen was routinely employed for collapse and general fill deposits. Activity areas and suspected midden areas were treated specifically with smaller mesh screens or completely collected for laboratory sorting and flotation. The same Strategies were used for the special features, which were either collected in total or screened using a quarter-inch mesh. All collections were processed in the field laboratory and cataloged by major artifact classes. These data were input and stored in computer files for analyses.

Field excavations followed natural levels and records were maintained by cultural Strata. Excavations proceeded with hand tools (shovel, pick, pick-a-hoe, trowel, and scoops), except where special deposits demanded a finer touch. All ceramics and lithics larger than 2 cm were collected in the field from screens for later analysis. All bone, obsidian, and miscellaneous artifacts were kept as well as any organic samples in quantities sufficient for C14 dating. Strata were identified visually and described using Munsell colors and an inclusion guide from the Portland Cement Association (PCA) handbook. Strata were defined in terms of soil type (i.e., sandy loam, etc. from the PCA Soil Primer), dry soil color (with a Munsell Soil Color Chart), and size, type, and percentage of inclusions (sizes range from boulders, cobbles, gravel and pebbles; type generally ranged from limestone to chert).

In preparation for consolidation, excavation of collapse and /or earth disturbed by looters was sometimes necessary and was handled in a different fashion from the formal excavations. Natural Stratigraphic levels were followed as much as possible and the excavations proceeded with the traditional hand tools. The back dirt from these areas was visually screened for artifacts from these disturbed contexts rather than mesh screened.

Previous Work at Tzunu'un

Attention to the residential component of El Pilar represents an important facet of the El Pilar Program as households were the foundation of the Maya civilization. Tzunu'un has been the focus of archaeological work of the BRASS/ El Pilar Program since 1984 when it was first located on the El Pilar settlement survey transect. At that time, the residential site was mapped within the survey area and tested as part of the 12% sample of residential units along the El Pilar transect.

In the subsequent full-scale excavation phase, we examined a representative sample of large, medium and small residential units in all the survey transects. Expanding the sample to include specific residential units at El Pilar, the large residential unit of 272-025 was selected for detailed examination. Named Tzunu'un, this group is one of two designated residential units at El Pilar selected for full-scale excavation. When this phase is complete, an excavation sample of 10 residential units to characterize households in the Belize River Area will be achieved.

Since 1996, we have proceeded to uncover the Structures of Tzunu'un, one of El Pilar's largest residential compounds. The 1996 excavations focused on identifying activity areas around the group and defining the dimensions of the two larger mounds, Str.1 and Str. 2. To accomplish these tasks, we prepared the initial map and conducted posthole tests 20 meters around the plaza to evaluate the type and context of activity areas. In addition, we tested the two principal and largest Structures, Str. 1 and Str. 2, to determine the condition of the buildings. This included corner probes and a small plaza trench in front (north) of Str. 1. Finally, we cleaned and profiled the looter's trench of Str. 1 and prepared initial construction sequence profiles.

The excavation research at Tzunu'un in 1997 continued the research plan initiated in 1996. The objectives of the 1997 season initiated the arduous task to expose the Structures of the courtyard plaza and interpret the construction history, function, and the overall plan of the group. Excavations began with the largest and most complex Structure, Str. 1, originally delimited in 1996. In addition, three other Structures were exposed. These included Str. 3, Str. 4 and Str. 5 and verified their basic foundation shapes and extents.

In 1998 excavation research concentrated on Str. 1, now defined as a residential range building, and Str. 2, identified as an eastern shrine. Building on previous years' investigations,

excavation concentrated on solving questions arising in rear of Str. 1 as to the nature and extent of the back rooms. Inquiries in to Str. 2 examined the history and morphology of the building. In addition, cross-plaza excavations added to an understanding of how the Structures related to each other in the public space, assisting in confirming temporal relationships.

The 1999 Season at Tzunu'un

The aims of the 1999 season, were designed to bring closure to the major excavations at Tzunu'un and to prepare the Structures for presentation to the public as one of the signature features of El Pilar in the Maya world. Excavations of Maya monuments have traditionally concentrated on public architecture. At El Pilar, the emphasis is on domestic architecture-reconStructing houses, replanting a garden with crops used by the ancient Maya, and generally creating a sense that people actually lived here.

To accomplish our aim to give a sense of the people who actually lived at El Pilar, specific tasks had to be undertaken. Aspects of the chronological and construction issues had to be resolved for the main southern range building, Str 1, and the eastern shrine, Str 2. Clarification of specifics and analyses of the general plans provided the data needed to proceed with the consolidation and presentation of the Tzunu'un residential unit. The detailed study established the interpretive basis for presenting the Tzunu'un group for view.

Methodology of Excavation

Although we had all the documentation from the previous year's work; there were difficulties with the locational references. To create a reference, we established a 2 x 2-m grid that is linked to the general system of mapping at El Pilar through the control point system of El Pilar. The site grid over the Tzunu'un area and use a local El Pilar control point in the center of the patio at Tzunu'un as the general grid reference. The numbered co-ordinates, for Tzunu'un, correspond to the South East, South West, North East or North West around a central point of the grid at the El Pilar local control point designated as 0,0.

The grid was positioned with the transit along arbitrarily defined principal axis at the El Pilar control point. Stakes were set every 2 m in the excavated area, and lines were setup along the excavation units: S 0.00 and S 12.00 also E 0.00, E 10.00 and E 12.00.

The standard excavation unit was 2 x 2 m, although, in special cases, we modified unit proportions and defined by specific coordinates. We excavated in natural levels: the humus, then the loose collapse, finally the Structural remains of architectural elements floor elevations, or simply a level. The excavated material was screened through a 1/4 inch screen, and collections processed in the field laboratory at BRASS Base.

Excavation and Results of the Range Building

Two operations were opened, exposing the north façade of Str. 1, the southern range building, advancing our research as to the access to the residential range building. Knowledge of the ancient access and the current state of preservation are essential to preserve the Structure for future generations and reveals a picture of the day-to-day uses of the ancient Maya who once resided there.

To fully consolidate this Structure, it was necessary to reexamine the architectural features exposed in 1998, including the three steps of the entry stair. We set up the excavation units based on the local Tzunu'un grid as follows.

1 –6.00 –2.00
2 – 6. 00 +5.20
3 –8.00 – 5.20

4 –8.00 +6.00
5 –9.00 +6.00
6 –9.00 +10.00
7 –12.00 +10.00
8 –11.20 + 4.00
9 -10.00 +4.00
10 –10.00 –2.00

The excavations began in the extreme north east of Str. 1 and continued to the west, in an attempt to fully define the architectural features. The excavation units proceeded in horizontal levels, advancing from the plaza towards the Structure, moving from the north to the south. The intent was to encounter the first changes in the level or the floor of the plaza and advance southward, exposing the architectural remains that were present.

The state of conservation the front of Str. 1 was not good. In the beginning we encountered large stones from the cornice, or the medial molding. In addition bits of modeled stucco we revealed which must have come from a frieze on the Structures' north east corner. This evidence was the result of the collapse of the upper zone of Str. 1 on to the terrace and the steps in front of the Structure. The interesting part of the east façade is that it gives the impression that the ancient Maya were in the process of remodeling Str. 1 but were interrupted.

On the west, other architectural elements were found over the stairs in association with the presence of more volume. Based on this, it appears that the deStruction of the stairs as well as the façade of the platform on the east was due to remodeling as represented by the Wall 1-20 (sections D 12 and D 13 as well as the plan view D1). Close examination of Wall 1-20 shows that it was made with recycled facing stones as well as many unfaced stones. The intention is clear, the ancient occupants were in the process of expanding the surface of the terrace to the front of the range building on the west side and either renovating the building or intending to use it as a base for new Structures. The artifacts recovered from the fill and exterior of Wall 1-20 date to the Terminal Classic Period and the beginning of the Early Postclassic, indicating a very late activity. (D 11).

It is probable that the modifications were initiated when the Str. 1 began to need repair. The renovations to expand the terrace utilized materials from this collapse. The data suggest that the activity was interrupted without meeting its final goal. The fact that the staircase is in a state of deStruction in some sections, where normally it would have been a well preserved, seems to demonstrate this. The construction project was clearly abandoned, and the remodeling of the façade of Str. 1 was never fully completed.

The Range Building: Structure 1
Architectural Interpretation

The deStruction of Str. 1 of Tzunu'un was so great, it is very difficult to understand all of its incarnations. This is aggravated by the presence of two or three looters trenches, including one which was terminated in a tunnel from the back of room 2 in the north west corner. The evidence of renovation complicates matters still; there are certain patterns that are repeated across the Maya area, which can be applied in this case. By examining the functions of the elements identified in the excavating, these patterns can be used to determine how the Structure may have appeared during use, and what may have been the final outcome of the remodeling, if it had been completed.

There exist certain patterns or tendencies in Maya construction. There are principals that are evident in the planning of interior space that can help us to understand what we are seeing at

Tzunu'un. A major Structure in the Maya area is composed of essential parts. These parts are defined in terms of the building process. They begin with the base and build up to the superStructure as follows:

1. The surface of the foundation or platform supports the entire Structure.
2. The platform made up of a solid mass elevating the Structure to a determined height either with one terrace, as in the case of Str 1, or a number of terraces creating a pyramidal Structure such as EP 7 at El Pilar.
3. The staircase with steps that rise from the base level, or level of the patio or plaza, to the level of the highest part of the platform to access the interior of the building.
4. The platform slab established over the upper terrace level to support the load bearing walls normally as one level, but can appear as two, or three levels depending on the design. This slab appears as a basal molding that surrounds the building once the bearing and exterior walls are in place.
5. The building, or superStructure, constructed on the platform slab: a house, palace or temple, depending on the construction.
6. The roof (masonry, wood, or palm thatch) supported by the bearing walls.

A standard basal molding for Structures is a basic component of Maya architecture. This component raises the elevation of the superStructure several centimeters above the platform terrace, while at the same time supporting the walls. It was initially interpreted that Str 1 had two basal moldings, yet this is not frequently found in the Maya area. Normally, there is only one molding. Below the molding of Str. 1, there exists the upper platform terrace that forms a front walkway of the building. This element would continues around the entire Structure to allow passage to the rear of a Structure. In some cases, it may narrow such that it may be interpreted as a molding. To ascertain the validity of the second molding of the Tzunu'un Str. 1, it was necessary to analyze the floor levels inside the building and compare them with the evidence of the exterior molding.

The analysis the levels of all the floors inside the building of Str. 1 were examined for level differences. The result revealed no evidence of changes in the floor levels in the interior of the rooms. Consequently, there would be no level changes expected or reflected in the exterior.

Given the levels of the platform terrace, the foundation slab, and the interior room floors of Str 1, it became clear that a standard single molding was the case and the interpretation of the west façade should be reflected in the findings on the other three sides. Unfortunately, only a small potion of the east façade was recovered intact. This, however, corresponds to the north façade and is sufficient evidence from which to draw conclusions.

The north façade shows a direct relationship between the access step and the main entrance of the building. The molding displays a variation in levels due to slumping and deterioration suffered over time. The slumping effected the level of the basal molding, making it appear discontinuous. Analysis shows the representation of a single level throughout the Structure.

Bringing the evidence together, we concluded that the initial interpretation of two moldings on the west façade is not justified. Instead, a single molding fit the findings on the north and east facades. This evidence from the north and east façades is used to present Str 1 as a reasonable, aesthetic, and technical rendition for public view.

Turning from access ways to Str 1, we have some difficulties to address. There appears to be no direct passage between Room 1 and Rooms 5 and 6. This implies that there was an access way from the south. These data were initially unclear and required a sequence of remeasurements

and reexaminations to collect the essential data to understand the construction sequence and its collapse.

The remains of the walls at the southern limit of Room 2 were initially defined as a exterior walls of the Structure. Careful analysis, however, proved that it could not be the exterior walls. The foundation slab, on which all bearing walls are constructed, forms a basal molding, as described above. This was evident on the standing external walls of Str 1. Examination of the southern walls shows no evidence of the basal molding. Instead, there is a floor that corresponds exactly with the level of the floor of the front Room 1. This confirmed two points: 1) that there are no changes of elevation between the existing front and floors of the Structure and only one slab level and exterior molding, and 2) that the existing wall remains on the south of the Structure represent an internal room divider rather than an external wall.

When attempting to examine the diStribution of room space within Str 1, it is necessary to take into account several issues: the degree of deStruction, the possibility of an abandoned remodeling phase; and recycled collapsed remnants of this same Structure. In analyzing the rear, or south, of Str 1 it is critical to consider the construction techniques.

Excavation showed that the ancient Maya used poor terrace fill constituents dominated by small rounded stones in a weak binding matrix of similar to sandy clay and marl. These types of fills are very unstable and do not provide a Strong Structural base or platform, This is especially true when water mixes with the fill and the clay matrix expands, changing in volume and causing lateral pressures that provoke collapse (section D 14). While we cannot reconStruct this architectural element, it must be considered as part of the interpretation of the Structure. The vestiges of floor contain cracks and slumps as one moves to the south. It is clear that this section of the platform terrace completely lost its ability to support the building it has now completely disintegrated.

Based on these interpretations, we propose that there was another room (Room 6) rather than a corridor between rooms 4 and 5 (see plan D 1). The southernmost bearing walls, along with basal molding, either had been removed during the remodeling process or collapsed due to the instability of the platform terrace.

To better understand this interpretation, more excavation will be required in the a future. We recommend a longitudinal sounding to provide evidence to clearly identify the relationship between the interior floor and the exterior basal molding (section D 9). This would confirm the interpretation presented here that Str 1 at Tzunu'un conforms to the regional Maya building norms.

In conclusion, during the Late Classic Period, Str 1 consisted of a rectangular platform terrace, overlaid by a foundation slab with walls making up a range building. It was accessed by a broad stairway containing three steps leading to the north façade and central doorway. There were no doorways between the north and south rooms, thus it would have been necessary to have been a similar entrance on the south façade into Room 6. The front terrace, or walkway, narrowed on the east and west sides of the Structure, would have encircled the building allowing passage from the north to the south entrances.

The Eastern Shrine: Str 2
Excavation, Results, and Architectural Interpretation
We see Str 2 as a small residential shrine, or temple. The interpretation and presentation of this household shrine is complicated by the latest activities around the Structure. There was, most recently, looting that deStroyed the rear (east) side of the building. But, there appear to be other activities represented by remodelings that were left incomplete and thus confusing the situation. Several construction phases were exposed and visible. These construction phases

appear to have been reStricted to the platform terraces, with staged enlargements over time. The upper building, or superStructure, however, shows no indication of similar modifications.

Str. 2 was not the focus of a large scale excavation. We reevaluated the looters trench on the east, analyzing the fills to establish a construction sequence with respect to the plaza floor. This was not very successful due to the extent of deStruction to the platform terraces. In addition, there was very little evidence of the rear wall of the Structure, only traces remain and it appears that the they were purposely removed, perhaps by the looters.

Examination of the remains of the tomb disturbed by the looters indicates that it was constructed prior to the latest building phases represented in the front of the temple. Combining the early phase of the tomb with the later architectural characteristics of Str 2, it is clear that the function of this Structure is ceremonial. The conclusion that this building is a temple or shrine is supported with this evidence.

The front or west façade of Str 2 was primarily excavated in 1998. This season, we cleaned the Structure to the platforms for the consolidation. The result of this cleaning defined the base of the principal, or west, façade of the building. A rectangular element was located in the center of this façade that appears to have been a narrow step, or possibly several steps, utilized during the final remodelings of the Structure

The superStructure of this household shrine is comprised of a building with two rooms. A spine wall with a central door divides them. The evidence for the spine wall and the division of space into two rooms is indicated by a small remnant of the step between the rooms and the base of the door jamb to the north of the doorway. Room 1, or the principal room, has a bench located against the north wall. This is well preserved and contained a central niche.

As with Str 1, the collapse and deStruction of Str 2 is significant. The scale of deStruction is not proportionate to the excavated ruble layer. It appears to be the result of something more than a simple collapse. The impression from the excavation is that the deStruction was intentional. It may be that this is another example of an episode of unfinished remodeling. This even may be an alternative explanation for the absence of facing stone in the looters trench. The ancient Maya, too, may have deliberately removed them, further bolstering the hypothesis of intentional deStruction.

Methodology and Theoretical aspects of Conservation at Tzunu'un

The El Pilar program has established clear guidelines for conservation at the site. These have been outlined in the 1997 report. In light of this seasons work, we will discuss here some of the key points in defining certain conservation actions and modifications are worth discussion.

As theory and methodology are put into practice, fundamental principals must be born in mind. These are outlined by the Venice Charter, an International document, that we applying to the cultural resources of the Maya. The theoretical concepts and ideas of the Venice Charter are important, however in practice characteristics of each monument have to be considered and taken individually into account. The Venice Charter says:

ARTICLE 9. The process of restoration is a highly specialized operation. Its aim is to preserve and reveal the aesthetic and historic value of the monument and is based on respect for original material and authentic documents. It must stop at the point where conjecture begins, and in this case moreover any extra work which is indispensable must be distinct from the architectural composition and must bear a contemporary stamp. The restoration in any case must be preceded and followed by an archaeological and historical study of the monument.

... [and} …

ARTICLE 15. Excavations should be carried out in accordance with scientific standards and the recommendation defining international principles to be applied in the case of archaeological excavation adopted by UNESCO in 1956.

It is clear that restoration is an operation of exceptional character. The sole objective of the restorer is to preserve. Site specific conditions at Tzunu'un, however, must be taken into account where advanced deterioration has made it difficult for the public to understand.

The objective at Tzunu'un is to enable the visitor to appreciate the monuments with minimal explanation from signage or tour guides. In accordance with this aim stabilization is indispensable. Often elements of a Structure need to be established for aesthetic and technical reasons in order to make the building more understandable.

In archaeological circumstances, if an object does not exist, or was completely deStroyed, one cannot replace it. Yet, in architectural terms, it is Straight forward: if the Structural element existed, but is broken, then it is within our power to restore or bring back the Structural efficiency to the architectural piece and make it understandable.

In the case at Str 1 we encountered a problem where the standard states there should be no reconstruction beyond what is found through excavation. In this instance, we also have to take into account that the same standard argues for stabilization with respect to aesthetic and technical purposes. It may sound like an internal contradiction to reconStruct elements or replace missing pieces, but, this is a case it was clearly necessary to include an object that once existed but has now deteriorated.

Given that the objective is to make a monument understandable to any viewer visiting the site, an element supported by evidence can be refurbished. In doing so, we must never go further then what was authentically probable. The authenticity of the monument must be maintained and there must be a clear differentiation between where the authentic ends and the hypothetical begins.

This interpretation with respect to the architectural composition is explained clearly in the ICOMOS Burra Charter. The Burra Charter establishes:

ARTICLE 19. Reconstruction is limited to the reproduction of fabric, the form of which is known from physical and / or documentary evidence. It should be identifiable on close inspection as being new work.

In this document, they use the term reconstruction to refer to what the Venice Charter mentions only as indispensable compliments. But we can also define the work as something that should be distinguished as new on close inspection but is in harmony with the architectural composition as a whole.

The Burra Charter also alerts :
ARTICLE 8. Conservation requires the maintenance of an appropriate visual setting, e.g. form, scale, color, texture and materials. No new construction, demolition or modification which would adversely affect the settings which adversely affect appreciation or enjoyment of the place should be excluded.

The intention of making the Structure understandable to the layperson is separate from defining the new work in a way which maintains the architectural integrity of the composition, This is basically put as the as form, scale, color, texture, materials of the architecture. Since 1997, the conservation work at El Pilar has been undertaken with these thoughts in mind

For the consolidation at Tzunu'un, we have maintained the texture of the building by using the same materials as those used by the Maya. To distinguish at close view, we have placed aluminum nails at the point of contact between the replacement stones and the originals. It is as though making a repair on a cloth that has deteriorated, you cannot use another color or texture, yet at close inspection you should be able to see where the repair was. The aluminum nails serve precisely that function. They delimit the compliment and put the seal of our time period without detracting from the composition of the building.

Range Building Consolidation: Str 1

The 1999 season completed the main goal to bring Tzunu'un as the first house compound to be exposed and consolidated for public view in the Maya area. There were 9 activities to the consolidation of Str 1:

A. East side with the bench. The interior as well as the exterior
B. East facade consolidated the original molding and the inset corner.
C. Stabilization of the original remains of the south east angle with the face of a bench of the room.
D. West side molding and collapsed compliment of part of the face to give a better interpretation for tourism.
E. The stairs or the fraction of the stairs on the north side were stabilized including one compliment of the floors over two of the steps with the objective to eliminate water filtration.
F. The Wall 1-20 that represents a modification that was never finished was consolidated without creating any elements except the substitution of disintegrating stones
G. A cap of new plaster was laid to protect the original interior floors, beneath this cap we placed sand which and can be removed if necessary without damaging the original plaster.
H. The corozo thatch roof was dismantled to allow the building to acquire a petina over the walls and to if there is a need for a roof to protect the Structure for the future. The 1999/2000 rainy season will provide data on this experiment.
I. Finally, we stabilized the fills of the excavations and backfilled those that will not be displayed to the public. Stabilized surfaces were planted with grass.

Revealing the Eastern Shrine: Str 2

The difficulty of presenting and displaying Str 2 is encompassed in the superposition of the various remodelings, several of which were exposed during excavation. These remodelings make it difficult to define limits in a way that is readily interpretable by visitors, in accordance with the Venice Charter. Overall, the remains were stabilized and left in a manner demonstrating that the west wall is a modification and the final additional stair that has been superimposed over the original platform terrace.

Due to the expedient nature of the final, but incomplete, Maya remodeling, it was decided to maintain the first version of the Structure as the primary focus for display, and to incorporate sections of the modifications to the north of the central axis of the Structure. The southern section was in a bad state of collapse, and would prove confusing to the layperson. Therefore, it was concluded the best option would be to cover up the majority of the south and focus on the south central to northern sections of the west façade. To the north the platform terraces are easily recognized and understandable.

The remaining sections of the temple were consolidated with minimal addition of elements. Decomposed stones were substituted with quarried stones at the door jamb and in the bench.

This defined the forms of the architecture, making them more interpretable. Unfortunately, there was very little left of the rear, eastern room. The scant remains, however, were stabilized.

Grass was planted on the areas covered to give the appearance of a mound. In addition after stabilization the linking extension between Structures 1 and 2 was backfilled and planted with grass.

Tznunu'un Drawings
Documentation in the form of drawings were established in 1998. The 1999 defined the details of architecture, Structural elements, and the relationships among them. Using this as a basis, we were able to revise the 1998 illuStrations and adapt them to the coordinate system.

We developed an entirely new general plan for Str 1 that is tied directly to the local grid of Tzunu'un. This general plan can be used as a reference for all the section drawings and profiles. The 1998 preliminary plan is used in this report with adapted coordinates to fit to the current system. Elevations were reconfirmed based on the 1999 coordinate system.

List of Drawings for Tzunu'un Consolidation:

Structure 1	**Stucture 2**
D1 general plan 1998 99	D17 Profile section N 10.75 1999
D2 profile section A-A 1998	D18 Profile section S 0.00 1999
D3 profile section C-C 1998	D19 profile section S 1.25 1999
D4 profile section D-D 1998	
D5 profile section E-E 1998	
D6 profile section F-F 1998	
D7 profile section G-G 1998	
D8 profile section H-H 1998	
D9 profile section I-I 1998	
D10 North face 1999	
D11 Section E 0.00 1999	
D12 Section E 2.10 1999	
D13 Profile section E 4.0 1999	
D14 Profile section E 5.2 1999	
D15 Profile E 5.2 1999	
D16 Section E 10.00 1999	

Protecting The Foundations ~ Str 3 , Str 4, and Str 5
While Str. 1 and Str. 2 were constructed of stone masonry, the other remains of the other Structures were mainly of perishable materials. The evidence of their locations is signaled by stone alignments identifying foundations that surrounded floors. Structures 3 and 4 were constructed on the northern limit of the plaza at Tzunu'un. It is clear that they are situated on the edge of the platform that supported the group Structures.

The advanced state of decay evident at Structures 3 and 4 meant that it was not possible to leave the Structural elements exposed to weathering. Therefore roofs were constructed over each of the foundations, protecting the remains while also providing an example of what these houses may have looked like when they were in use. In addition, we wished to display the construction techniques of these perishable Structures. Str. 3 has been left showing several different phases on the construction process of a wattle-and-daub Structure.

Table of Champa Construction

To be inserted

We anticipate the possibility of trampling by tourists, which never fails to occur when groups visit and will walk on the original surfaces that are presently conserved. We have put plastic tapes to inhibit access but a more formal method of discouraging tourists from walking and entering on these original floors may be required. It is clear that the caretakers of the site will protect these Structures reducing the possibility of problems. Also, the first year of visitation will allow analysis of this issue.

It is our intention to leave these houses in the process of construction with the objective to protect the foundation and floor remains of the houses and leave a clear example of the construction methods of houses of this type: rustic wood and roof thatched with corozo leaves. . The processes used in the creation of this protective and informative building are the same techniques used by Maya in the local area today.

The foundation of Str 5 is situated on the extreme west of the plaza. The basic was consolidation of the walls and protection of the floor was completed in 1998. Examination of the level of preservation maintained over the last year suggest that it is unnecessary to build a roof for this Structure. The initial consolidation was completed to produce secure surfaces and the addition of a firm horizontal cap including small stones to enhance drainage has created a monument that will withstand future weathering. From the remains that were in situ it is probable that this house was not constructed of rough wood but constructed of a combination of masonry walls and a combination of roof made of wood and palm.

DEFINING THE MAYA FOREST GARDEN

Though the El Pilar Archaeological Reserve contains a complex array of evidence of the ancient Maya, the flora and fauna of the reserve are equally complex. The trees, herbs, mammals, birds, and other animals and plants certainly defined much many of the practices of the ancient settlers of this land and continue to play a role in more recent time. To compliment our work with traditional farmers, we are also collecting data for understanding light requirements for planning future garden developments (Appendix #)

The Maya Forest Garden Program began during the 1996 field season of the BRASS/El Pilar Program as a means of demonstrating the potential use of managed forests and house gardens by the ancient Maya. Plants located within the garden are representative of plants utilized by the Maya for construction, medicine, food, and a variety of other purposes. Many of the plants also have an associated rich folklore and historical context, detailing a continuing association of the people and the flora of the region.

Information on the plants used by the ancient Maya comes from a variety of sources. Some of the most crucial plants for the Maya, including corn, the ceiba tree, copal, and cacao are depicted on vessels and in other art forms. Other direct information comes from analysis of the minimal seed and plants remains. Further evidence comes from the continuance of many traditional practices in the Maya region, suggesting that many of today's uses of the regional flora also occurred in the past.

With collaboration from local informants knowledgeable in the plants of the area, more than 150 species of trees and herbs in the forest garden have been labeled and given a number for later identification. Nearly 700 plants in the Tzunu'un area were marked, most of them not even on the trail. Though we ask that you generally stay on the trail, you are welcome to go off the trails to read the plants tags or to get a closer look at individual plants. Tags on the plants normally contain the plant's number, one or two of the most commonly used names, and the scientific name when known. For more information on some of the most commonly labeled plants, see the appendix at the back of this guide.

There are over 150 species of plants marked on the El Pilar Archaeological Reserve, each with its own ecological and botanical characteristics, ancient and current uses, and traditional lore. The guide we have developed includes information on some of the most common identified trees and herbs in the forest garden and along the trails of the reserve (Appendix II).

Insert Paul Bailly's new plans

PARK DEVELOPMENT, COMMUNITY RELATIONS, AND PARTICIPATION

Each season, the BRASS/El Pilar Program crew teams up with the El Pilar Caretakers and Amigos de El Pilar to look at the issues of maintenance at the site. In the past few years we have also collaborated with Help for Progress as the community participatory component has accelerated. We regularly work with trouble-shooting on trail development, examining exposure problems, and discussing options and solutions to issues of concern. We also included the Department of Archaeology in these discussions as they are the Government managers of El Pilar. This season we coordinated the construction of two sets of El Pilar latrines. This was funded by the British High Commission in Belize, managed by Help for Progress and BRASS/El Pilar, with labor supplied by Raleigh International volunteers. In addition to the activities in the EPAR boundaries, we also work in Bullet Tree Falls at the Be Pukte Cultural Center, and this year included coordinating the creation of the Masewal Forest Garden Trail with Raleigh International.

Park InfraStructure.

As part of the BRASS/El Pilar Program's ongoing efforts to develop the infrastructure of the EPAR two, four-stall latrine blocks were constructed at El Pilar. The generous support of the British High Commission in Belize funded the materials, Help for Progress supported planning and logistics, and the BRASS/El Pilar program was involved with the daily oversight. The latrines are located for visitor access, one set near the entrance of the Lakin Trail and parking area in the south of the site and one set west of Plaza Duende in the middle west of the site. These are excellent locations for access and use by visitors to El Pilar

We can now celebrate a needed and welcome addition at El Pilar. Everyone has heard of Teo Williams' Ergonomics of the Field Toilet (*Teo's Way* pp. 8), that is now a thing of the past. Volunteers from Raleigh International spent time with AdEP and the El Pilar Program divided between the trail of the Masewal Forest Garden and the construction of comfort stations at El Pilar. These two sets of latrines were built to last. Directed by project foreman Carlos Medina, these elegant amenities feature four *long-drops*, two on each side of a sink serviced by roof-shed rainwater and collection tanks. They are easily found ensconsed in the visitor areas.

Masewal Forest Garden Trail Inauguration

On March 31st, members of the El Pilar crew, AdEP, and community members met to inaugurate the formal opening of Heriberto Cocom's Masewal Forest Garden Trail, an new feature in the village of Bullet Tree Falls. The event was hosted by Don Cocom and Raleigh International, who volunteered to design and prepare the Forest Garden trail through Don Cocom's traditional farm, located along the river about 2 km from the AdEP Be Pukte Cultural Center.

This was a gala event with a formal opening of the Belize National Anthem by school children and presentations of key participants in the creation of this trail. The formal events culminated with the confirming of agreements between AdEP and Don Cocom by signed by the JP and witnessed by all present. SEN TV covered the momentous event, and Cayo viewers who missed the festivities enjoyed a real-time airing. The finale was a sumptuous lunch hosted by Raleigh for all the crowd.

Breaking New Ground: Community Development at El Pilar

Community development events associated with El Pilar were multiple. Work proceeded with Amigos de El Pilar under the direction of the NGO Help for Progress, the El Pilar Program crew, Belize Peace Corps, and government officials. Activities included capacity building within Amigos, mobile study-tours to nearby archaeological tourist sites, crafts workshops at the Be Pukte Cultural Center, and preparation for the annual general meeting.

These activities were designed to forge Strong ties among the diverse, yet related, components of the El Pilar Program.

The community participatory component of El Pilar is unique from any other aspect of the project. Unlike the archaeological, ecological, and management components of El Pilar, the community aspect exposes the deeply felt sentiments of how nearby residents interact with their landscape and plan for their future. This makes the community component of the El Pilar Program one of the most challenging and exciting aspects of this groundbreaking work.

"Taking the Challenge"

The program's notable mantra for El Pilar, "Taking the Challenge," is particularly relevant for community development. This unique archaeological and nature reserve on the Belize/Guatemala border has compelled the adjacent community to reconsider their connection to the El Pilar area.

Historically, members of the community used the El Pilar area for hunting, logging, chicle harvesting and other non-timber extraction, as well as milpa farming. Asking these communities to see El Pilar as a different type of resource has been a challenge indeed. Rising to this challenge, the BRASS/El Pilar Program has utilized a rich network of individuals and organizations ranging from grassroots community groups and communities leaders, to government officials, scientific experts and committed non-government organizations (NGO). A critical NGO in the El Pilar picture is Help for Progress, Belmopan, Belize. Focusing on education, economic development, and organizational capacity building, in interdisciplinary work at El Pilar continues to break new ground by making community development a project priority.

El Pilar Community Development 1999

Educational efforts were directed toward community knowledge regarding Maya heritage, ecological preservation, and presentation of archaeological sites. During the 1999 field season, these efforts included visits from both Belizean and U.S. school groups. Students from Santa Elena Upper Primary, Bullet Tree Falls Primary, Georgeville Primary, and Laredo Middle School, Colorado under the supervision of Carmeny Thorpe (USA) visited El Pilar to learn about the ancient Maya and new reserve conservation techniques.

A major educational capacity building program was a series of four workshops, or *tallers*, supported by funding from the Canada Fund and the BRASS/El Pilar Program. The goal of these mobile study-tours was to increase AdEP members' knowledge of development options for archaeological reserves. AdEP members made trips to nearby ancient Maya sites such as Caracol, Xunantunich, Cahal Pech, and Tikal. The lessons learned were then brought to a review workshop at El Pilar.

After these visits, AdEP members contributed formal written feedback regarding their observations and comparisons of community and economic development. These visits and workshops were successful on a number of levels. First, AdEP members gained vital new knowledge of the context of the Maya archaeology that allowed them to assess community and economic development at El Pilar. Second, these workshops strengthened the working relationship between AdEP, the El Pilar crew, non-government organizations (Help for Progress and Caanan Kax), Melchor community members and government officials, all who were involved in these events. Finally, the exposure provided by these workshops encouraged community members to become more directly involved in community and economic development at El Pilar.

Development efforts sought to increase understanding of economic opportunities available to community members through the El Pilar Program. During the field season there were also an educational workshops and periodic needs-assessment discussions. In May, Peace

Corps Volunteers gave a papermaking workshop at the Be Pukte Cultural Center. Volunteers demonstrated how paper could be made from native plants and then turned into products desirable to tourists. Other economic development initiatives included assessment of the Be Pukte Cultural Center and gift shop.

In a series of meetings, Peace Corps volunteer Pat King and community and regional planning MA student Christine Ageton (U New Mexico), assisted AdEP members in assessing their economic goals for the Be Pukte shop, reviewing their product line, and discussing improvements. AdEP members formally explored the option of expanding the current cultural center into a small restaurant. Exposure to new ideas and assessment of economic goals and viability were the key successes of economic development work. AdEP members actively investigated how the presence of an archaeological reserve may alter economic development options. In addition, they focused on self-determination, i.e. which efforts best serve their needs and can be sustained without outside assistance.

Organizational capacity building sought to give the community the necessary framework for self-determinant planning that would uncover their goals and objectives for community development in conjunction with the El Pilar Archaeological Reserve. Organizational advances during the year represented some of the least tangible yet most significant gains. Members of AdEP worked diligently with NGO, Help for Progress, Peace Corps volunteer Pat King and Ageton to examine the Structure and goals of their organization. In a series of bi-monthly meetings they assessed the daily operations of AdEP and the Be Pukte Center including finances, sales and community goals. We also met frequently in late June to organize and plan AdEP's annual general meeting (AGM). In addition, Help for Progress sponsored an AdEP visit to Orange Walk to participate and observe the Las Orquidias (a similar community based women's co-op) AGM. Much of AdEP's success was due to their own examination of the organization's principles and objectives. The successful AdEP AGM held in July 1999 evidenced these advances. The large number of community development efforts during the past year is a testament to the deep commitment of all parties involved with El Pilar.

Struggles are Successes

Asking any community to embrace a project as unique and grand as El Pilar is bound to encounter some difficulty. However, it is important to note that Struggle is inherent in community development, and change and new understanding are impossible without discussion. For this reason, it is as important to look at areas that need improvement in community development at El Pilar as it is to celebrate this year's successes. The following items either illustrate success through Struggle at El Pilar or identify areas where improvement is needed.

AdEP's self-determination has become a paramount issue in the relationship between AdEP and the El Pilar Program. As the community/El Pilar relationship has matured, AdEP members have begun to look for more control over their development agenda. At times, this includes embracing projects or events that may not correspond with the development of El Pilar.

During the 1999 field season, AdEP members explored the idea of starting a restaurant as part of the Be Pukte Cultural Center although the necessary organizational and financial capacity to run this type of operation was not evident. This type of disconnect in agenda is both a success and a challenge. It shows that AdEP is becoming less dependent on the El Pilar and Help for Progress, and that they are embracing their own vision of how their relationship with the El Pilar project might develop. This requires an adjustment in the interaction and negotiation between the El Pilar project and AdEP.

The same is true for the communication and network building aspects of community development at El Pilar. During the course of the 1999 field season, members of both AdEP and El Pilar crew became fruStrated during periods of poor communication regarding workshop details. This is evidence that AdEP is comfortable voicing their concerns and assuming greater responsibility and input into community development. The challenge is to balance multiple

agendas of all participating stakeholders, by engaging in better communication as well as actively addressing network building.

During the 1999 field season, AdEP members identified low community participation as an issue they would like to address. Over the last few years AdEP membership has not grown, despite the fact that a survey conducted by AdEP in 1998 indicated that most Bullet Tree Falls residents support the El Pilar project. During the AdEP AGM, members noted that increasing membership would be a priority in the coming year.

Breaking New Ground

Community development at El Pilar has local, national, and international implications. Although more parks and reserves have been established on the past 20-30 years in Latin America than ever existed previously, there are still few reserves that explicitly incorporate community development into their models. In many ways El Pilar is leading the way by incorporating community involvement from the beginning. Moreover, it has become increasingly clear that reserve sustainability is impossible without local community support and commitment. Appropriate development will allow the community to define its own goals, take ownership of successes and failures, and include all stakeholders. By embracing Struggle and learning from differences, El Pilar has the potential to become a model for community development that Stresses process and longevity.[5]

BRASS / EL PILAR AND THE MAYA FOREST GIS

The BRASS / El Pilar - UCSB Maya Forest GIS project has focused on assembling available data to cover the greater Maya forest region. These data are now combined into a regional GIS destined to be an archived database in the Alexandria Digital Library (Smith and Few 1995).

Our compilation is based on the GIS developed at 1:250,000 by WCS (Wildlife Conservation Society) / Conservation International (CI) for the US Agency for International Development. We have integrated our digitized maps of topography and soils; included Saders (1999) land use data for the Peten; geo-referenced 11 MSS satellite images; incorporated the local GIS data base developed by Fedick (1989) for the Belize River area (topography, soils, settlement); and incorporated a 1998 1:6,000 photo-mosaic (Girardin 1999) of the El Pilar Archaeological Reserve. This first version we compiled specifically for the UCSB Maya Forest GIS has been shared with our collaborators in Belize and Guatemala. Compiled in ArcView format, the data include:

- Cultural Data (Country Boundaries, State, Department, and DiStrict Boundaries, Settlements, Roads, Archaeological Sites, Proposed and Existing Protected Areas and Study Boundaries).
- Physical Data (Rivers, Lakes, Bathymetry, Reefs).
- Biological Data (Belize Vegetation, Mexico Vegetation, Holdrigde Lifezones for Belize and Guatemala, Belize Forest Cover and Guatemala Forest Cover).
- Satellite Imagery: Landsat MSS Mosaics of the area with unsupervised classification.
- Data Indices for Topographic Quad sheets for Belize 1:50,000 and 1:250,000; Quad sheets for Guatemala 1:50,000 and 1:250,000 and Quad sheets for Mexico 1:50,000 and 1:250,000.
- Digitized soils coverage of Guatemala, Belize, and Mexico 1:250,000 and other scales (the nations used different soil classification systems, and rectification of the soils types will be necessary).

[5] *Note: C. Ageton would like to extend my gratitude to the University of New Mexico Latin American and Iberian Institute for their financial support. In particular, I would like to thank all of the members of the El Pilar 1999 crew, Amigos de El Pilar, Help for Progress, Canan Kaax and all residents of Bullet Tree Falls, Belize who generously donated their time and insight to the Program.*

- Topographic information collected from the Digital Chart of the World, by digitizing contour maps, and from other sources.
- Updated protected area boundaries and 1:50,000 topography for Guatemala.
- Site specific GIS data from scanned and rectified air photos at 1:6,000 and from field maps.
- GPS coordinates of the control point network for the El Pilar Archaeological Reserve.

The purpose of the GIS is to identify and compile discrete data sets as information layers using the UTM grid system as the geo-referencing connection among the information layers. The UTM gird system will allow distinct layers to overlay in one single coordinate system, creating a valuable GIS model.

The establishment of a tight UTM control point network at El Pilar provides for the basis of site specific data collection and integration into the GIS. These data will overlay local data and regional data for integrated and comparative study. Construction a viable GIS model will facilitate spatial analyses at El Pilar and help integrate related research accurately.

To achieve this objective, the spatial data need are compiled, integrated, and organized with the software ArcView into the GIS as layers of information. Data acquisition will be scaled from the small regional comparative layers to the large site specific data such as the excavations. These varied scales can be managed to organize of the Maya Forest research and analyses. Materials compiled at the different scales will be fundamental and complementary.

Data organization

To pursue the cross-scale Maya forest research linked to El Pilar, the three conceptual scales have to be managed together:

1- The small scale includes the Maya Forest region

The range from 1:250 K and higher and incorporates the whole Maya Forest (south Mexico, north Guatemala, and Belize).

2- The medium scale includes local focus

This scale ranges around the scales 1:50 K Ò 1:20 K and incorporates local areas such as El Pilar Cayo Ò Belize, Tikal in Guatemala, Nohmul No. Bellize, Caracol, Maya Mountains

3- The large scale is the site-specific level

This scale ranges from 1:6 K and less and concentrates in distinct search areas such as EPAR. The data are collected as inventories, maps, excavations linked to control points.

	Maya Forest	**Peten and Cayo**	**EPAR**
Topography	DEM or radar images	Quad sheets Or radar interferometry	Radar interferometry: 6 m relative accuracy EPAR paper sketch maps to know the location of the Maya settlements
Soils	Soils quad sheets		
Vegetation	Vegetation quad sheets		Air photos analysis
hydrology	WCS Database	Use topographic quad sheets	TerreStrial and GPS survey Natural and human-made data

Land use	Satellite images	Air photos analysis for Cayo -70s Complete with new air photos and survey	Air photos analysis + TerreStrial and GPS survey every year of the changes Need better coverage of the reserve
Land cover	Satellite images	Peten database from RBM	Air photos analysis + TerreStrial and GPS survey every year of the changes Need better coverage of the reserve

Moving through these scales and analyses is important and involves clear organization of the data in terms of the GIS. Management and maintenance of the data layers, updating data references, and integration of new data are critical components of the research. The quality of the information layers affects the overall analyses.

Future work at El Pilar will build on this GIS model creating a fundamental system for managing the spatial resources of the El Pilar Archaeological reserve for Maya Flora and Fauna. The value of the analytical results developed from the Maya Forest GIS will infom on ancient Maya settlement patterns, land use in the past, as well as cultural resource management issues. . The purposes of the research at El Pilar is to advance knowledge of land use of the ancient Maya and, simultaneously, to generate knowledge of direct use in the conservation of the Maya forest.

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Tedlock

Appendix I: Gathering and processing GPS data for archaeological mapping

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Accuracy and precision

Accuracy is used in the context of GPS mapping with Trimble's Pathfinder OfficeÙ software and receivers, the term can refer to different attributes.

1. The term refers to the confidence with which the absolute location of the receiver is known. If the base station is placed on a point of known location, then the accuracy is determined by the confidence with which that location is known.
2. If, however, the base station is placed on a point the location of which is unknown, then the base station reference position is determined autonomously and the accuracy is that defined by the department of defense for the L1 signal, 100 meters (2dRMS).
3. The term accuracy also can refer to a capability of a particular GPS receiver and is usually expressed as a constant plus a function of the length of the base line between the base station and the rover expressed in parts per million (ppm).

The term precision refers to the confidence with which the base line between the base station and the rover is known. The precision of a position is expressed as a unit length that is the error of the position in the northerly direction, the easterly direction and the vertical direction from the position's displayed coordinates. The precision of a feature is expressed as the average horizontal and the average vertical precisions of the positions that comprise the feature. Precisions are expressed at a confidence level, 68%, 95% or 98%, representing respectively one, two and three standard deviations of the diStribution of the data. In this report all precisions are expressed in centimeters at the 95% confidence level.

Differential code and carrier phase processing

There are two methods of differential processing used for GPS data: code processing and carrier phase processing. Traditionally mapping grade single frequency GPS receivers were used to collect data that was code processed and produced precisions that were better than 1 meter plus 2 ppm times the base and the rover given appropriate conditions of satellite geometry and signal to noise ration. Dual frequency survey grade GPS receivers were used by land surveyors to collect data that was carrier phase processed producing far greater levels of precision.
Single frequency mapping grade GPS receivers are very practical for archaeological mapping purposes. Relative to dual frequency survey grade receivers, they are economical, portable and rugged. They gather data rapidly for code correction. This degree of precision is sufficient for most archaeological applications. They are insufficient for such tasks as the mapping of monuments, determination of alignments of Structures, fitting of a local site grid to the Universal Transverse Mercator Grid system, or the generation of positions for fine scale topography.
Software developments now make it possible to use the carrier phase method of data processing with single frequency receivers to achieve typical horizontal precisions of 2 to 2.5 centimeters and vertical precisions in the neighborhood of 5 to 7 centimeters. There are, however, more Stringent requirements for data collection if one wished to use this method.

Differential Code Correction

GPS receivers generate the identity codes for the satellites synchronously with the transmission of the codes by the satellites. For code processing the critical measure is the time offset between the satellite transmission of the L1 signal and the receiver reception of the signal. The receiver shifts its generated code in time to match the code received from the satellite. The time difference multiplied by the speed of light is the distance of the receiver from the satellite. The position of the receiver is determined by solving the intersection of four spheres, the centers of which are the known locations of four satellites at a given epoch and the radii of which are the distances from the satellites to the receiver. With differential

correction, relatively short base lines, and good satellite geometry, this technique can produce sub-meter precision.

Differential Carrier Phase Processing

Carrier phase processing is an inherently more precise measuring device. The length of transmission of one bit of the code is 293 meters, whereas the L1 carrier frequency has a length of 19 centimeters. In both cases the signal is digitized and is phase modulated.

The distance from the satellite to the receiver can be thought of as being measured in a certain integer number of wavelengths of 19 centimeters each plus a fractional cycle. Since the signal is digital, the fractional cycle is measured as the elapsed time since that last phase shift. The receiver can determine the fractional cycle or phase to within a hundredth of a cycle or about 2 millimeters._ The unknown number of full cycles between the satellite and the receiver is called the integer ambiguity.

The phase processor software is able to determine precisely the location of the rover antenna by resolving this ambiguity. A search volume for the true position is created based upon the average and the standard deviation of the code solution. A least-squares approach is used to discover the unique set of assignments of integers to the satellite carriers that result in a single stable position. The three unknowns, the X, Y and Z coordinates of the rover receiver ought to be soluble from the carrier signals of three satellites. This, however, is not the case.

Instead of the carrier signals themselves, the program uses the differences between the carrier waves of pairs of satellites received by the base and by the rover receivers. These are called double differences. These are used because in the double difference expression the clock errors of the satellites and the receivers drop out of the equation. Signals from four satellites are required to produce three double difference equations. To test statistically for the best solution, the data must be over-determined. Thus, data from a minimum of five satellites is required for a carrier solution. The solution is Strengthened with a greater number of satellites.

For single frequency receivers to collect an adequate quantity of data to resolve the integer ambiguity, the base and the rover must maintain carrier lock on at least five satellites for a minimum period of about 45 minutes. While the number of satellites cannot be less than five, they do not need to be the same five satellites throughout the period.

Since all of the data are processed after the field survey, it is not necessary to resolve the ambiguities prior to gathering other data. The algorithm that the carrier phase software uses for resolving the integer ambiguity does not depend on the rover remaining in the same location for the 45 minute period, only that it maintain the carrier lock.

As the rover receiver is moved from place to place, a great deal of planning and care in execution is required to avoid loss of carrier lock in conducting the survey. Fortunately, planning software is available to aid this part of the process. The satellite signals are very weak and maintaining lock on the carrier phase is particularly difficult with any degree of forest canopy cover. While this method of data processing is very precise, it is only practical in open situations.

The accuracy of carrier phase processing is also a function of the distance between the base station and the rover receiver. For acceptable code processing, the base and the rover can be as much as 300 kilometers apart and still produce sub-meter results. With carrier phase processing the two must be much closer together. If the base is more than about 50 kilometers from the rover, the carrier solution will probably be no better than the code solution. For horizontal 95% confidence level precisions in the neighborhood of 2 centimeters or less, it is necessary to occupy a position with the rover as near the base station as a few meters for a significant period of time (c. 20 minutes) during the course of the survey.

[6] The frequency of the L1 signal is 1575.42MHz. At the speed of light, 300,000 km/sec, it thus travels 190.425 mm for every shift in phase. It shifts in phase once every 0.63 nSec and the receiver clock can resolve to 0.01 nSec.

GPS Field Practices

Field procedures

Standard settings and field conditions

All field procedures for data gathering assume the following conditions:
PDOP less than or equal to 4
Signal to noise ratio less than or equal to 6
Base satellite elevation mask set at 10º.
Rover satellite elevation mask of 15º
Synchronized measurements between the base station and the rover. The usual data synchronization interval is 5 seconds. For code processing the base station receiver can be set to a multiple of the rover interval and the software will interpolate the intermediate correction. For carrier phase processing the synchronization must be identical.
Code: If only code processing is to occur, carrier mode can be turned off on the datalogger, the mode can be set to manual 3D, and files can be opened, closed and reopened as convenient.
Carrier: For all data gathering for carrier phase processing, the carrier mode must be turned on, the mode must be set to overdetermined 3D. Files need to be left open to maintain continuous carrier lock and a file may not be reopened.
Static: In the classic static method of gathering GPS data the rover, as well as the base station receiver remains stationary on a point for some significant length of time. With single frequency receivers a minimum occupation of 30 minutes is required and 45 minutes is recommended. Change in the satellite geometry enhances the resolution of the carrier phase ambiguity. A separate file is created for each station so occupied.
This method is appropriate in circumstances where the highest degree of precision is required. At El Pilar baselines of almost five kilometers in length have been measured to the sub-centimeter level of precision using this technique.
Intermittent kinematic: The intermittent kinematic method is often called stop-and-go kinematic. Characteristic of this method is the successive occupation of a number of points with the rover receiver while maintaining continuous carrier lock not only during the occupations but throughout the process of moving as well.
As with the static method, with single frequency receivers, it is recommended that the file be open for a minimum of 45 minutes in order to use the change in the satellite geometry to aid in the resolution of the integer ambiguity.
To be successful with this method the lines from point to point must have a good view of the sky. Careful planning and care in moving the rover receiver is also very important to the success of this technique.
Initially occupy an with the rover an arbitrary point only a few meters from the base station for a period of 20 minutes, then rove, occupying each successive point for as little as 5 minutes. This method can produce results with precision that matches that of the static method and requires far less time in occupying each point. However, it does require that carrier lock be maintained on five satellites throughout the recording of the file. There are very few circumstances in the typically moderate to heavy canopy at El Pilar where this is possible.
Pseudo-static: With the pseudo-static method of gathering data a number of points are occupied by the rover receiver for a short period. The points are reoccupied by the rover receiver at least one hour later. With single frequency receivers a minimum of 5 minutes is required and 10 minutes is recommended. This method will not produce precisions equal to either the static or the intermittent kinematic method. However, if the number of positions to be occupied makes the use of the static method impractical and at the same time the cover makes the use of the intermittent kinematic impossible, then the pseudo-static is a logical choice. Unlike the case with the intermittent kinematic method, It is not necessary to maintain carrier lock from position to position. It is important that the time between occupations of the same position be at least an hour. The pseudo-static solution is Strengthened with the changing satellite geometry. The pseudo-static method is sometimes called the pseudo-kinematic.
Continuous kinemati: If the precision demands of the survey are not so great as to require the intermittent kinematic technique, it is possible to use a fully kinematic method that simply

does not stop. This technique can be productive for such purposes as gathering topographic data for contour mapping. As with the intermittent kinematic method, it is crucial to maintain a clear view of the sky. It also remains important to keep the file open for a minimum period of about 45 minutes.
Initially occupy an with the rover an arbitrary point as close as is reasonable to the base station for a period of 20 minutes, then rove with the datalogger set to record out-of-feature positions.
This method could be used to gather positions for topography provided the area is sufficiently open to maintain continuous carrier lock.
This method is sometimes referred to as ambiguity resolution on the fly (AROF) or simply on-the-fly (OTF).

Appendix II Forest Garden trail
Nicole Gerardo University of Texas, Austin

There are over 150 species of plants recorded in the El Pilar Archaeological reserve for Maya Flora and Fauna. Each of these plants has its own ecological and botanical characteristics, ancient and current uses, and traditional lore. The Tzunu'un Forest Garden Trail Guide is developing information for use at the site. We are including some of the most common identified trees and herbs in the forest garden and along the trails of the reserve.

ACACIA
Acacia cornigera (Mimosaceae)
Other Names: red cockspur, black cockspur, white cockspur, subin, zubin
The relationship between ants and acacias is an example of a common association in tropical forests, symbiosis. Symbiosis is the mututal benefit of two organisms. In this case, the acacia has hollow thorns which serve as homes for various ant species. In turn, the ants protect the acacia from herbivorous insects and from humans (be careful!). The sharp thorns also serve as a form of protection.

Acacia plants are also used medicinally to treat male impotency and asthma and snakebites.

ACHIOTE
Bixa orellana (Bixaceae)
Other Names: annatto, annata, ricatta

Achiote is a commonly used coloring in foods of the region, providing a deep red-orange color. It also adds a bit of flavoring. Achiote is similarly used in most of Latin America for food, as well as for body paint and dye. The coloring is extracted from the large, red seed pods which grow throughout the year.

ALLSPICE
Pimienta diocia (Myrtaceae)
Other Names: pimenta gorda, pimenta
Allspice are located in the forest garden and in many of the plazas of El Pilar. They usually grow in clumps of large bushes and small tree. They are easily recognized by their smooth bark and leaves which have a distinct spicy odor. The fruits of these trees can be collected, dried in the sun or over a fire, and utilized as a spice. Medicinally, the leaves of the plant are used for digestive upsets, aches and pains, low energy, menStrual cramps, and foot fungus.

BAYAL
Desmoncus quasillarius (Palmae)
Other Names: basket tie tie
Basket tie tie, as you may have guessed, is often used to make baskets. However, if you want a basket that you can carry without hurting yourself, care must be taken in handling this vine-like palm and Stripping the spines off first. If a spine does get under the skin, place wax over the spine hole and heat the area until the spine begins to emerge.

BAY CEDAR
Guazuma ulmifolia (Sterculiaceae)
Other Names: pixoy, guacimo, caulote, tapaculo, bastard cedar

Bay cedar is a common tree in the El Pilar Reserve. You may notice bay cedar's hard, spine-covered seed pods scattered on the trails as you walk along. The fruits of bay cedar are eaten by monkeys as well as cattle.

For stomachs and diarrhea, the bark is boiled in salt water and consumed. The gelatinous sap of the fruits is said to cure elephantiasis and can be used to reduce swelling. It is also used to treat dysentary, prostate problems, infections, and rashes.

Bay cedar is also used to make charcoal and cigar boxes.

BLACK ORCHID
(Orchidaceae)

The black orchid is the national flower of Belize. Though you might expect this orchid to have black flowers, it actually has beautiful purple and yellow inflorescences.

Black orchids, like other orchids, are often associated with ants that live in root mat of these epiphytes, plants that grow on trees. While the orchid provides the ants a home, the ants protect the orchid from other insects and those who try to pick the flowers. It's best to leave this flower alone for other visitors to admire.

BULLET TREE
Bucida buceras (Combretaceae)
Other Names: pukte, pucte, puk'te, bully tree, cacho de toro

As you traveled up to El Pilar, you passed through Bullet Tree Falls, the village named after this tree species. The tree, sometimes covered in bunches of small, pale yellow flowers, is seen growing along the banks of the Mopan river, which passes through the center of town.

Bullet tree is appropriately named – it is harder than a bullet and extremely difficult to cut. Because of its durability and water resistance, it is used as a construction material. It is also used to make railroad ties and charcoal, and the bark is used in the tanning of leather.

CACAO
Theobroma cacao (Sterculiaceae)
Other Names: ch'ol, kakaw

Cacao was one of the ancients Maya's most important beverages. Though likely consumed by all social classes, it was prepared especially for the ceremonies and festivities of the nobility. Cacao could also be consumed as a solid food. Because of its sacred importance and frequent use, cacao was likely an important trade item.

Today, chocolate, as a beverage, is still frequently prepared in the Maya region. The sweetened, solid form of cacao, chocolate, is likely its most popular use world wide. Chocolate is prepared by soaking the cacao seeds, grinding them, and adding sugar to the prepared powder.

CALABASH
Crescentia cujete (Bignoniaceae)
Other Names: luch, hom, huaz, tree gourd, wild calabash, jicara

In the Popul Voh, a Maya creation myth, the lords of Xibalba, the underworld, cut off the head of one Hunahpu, the father of the Hero Twins

> "And when his head was put in the fork of the tree, the tree bore fruit. It would not have had any fruit, had not the head of One Hunahpu been put in the fork of the tree. This is the calabash tree, as we call it today, or 'the head of One Hunahpu,' as it is said.
> And then One and Seven Death were amazed at the fruit of the tree. The fruit grows out everywhere, and it isn't clear where the head of One Hunahpu is; now it looks just the way the calabashes look. All the Xibalbans see this, when they come to look.
> The state of the tree loomed large in their thoughts, because it came about at the same time the head of One Hunahpu was put in the fork. The Xibalbans said among themselves:
> 'No one is to pick the fruit, nor is anyone to go beneath the tree,' they said. They reStricted themselves; all of Xibalba held back.
> It isn't clear which is the head of One Hunahpu; now it's exactly the same as the fruit of the tree. Calabash tree came to be its name, and much was said about it. A maiden heard about it..."[7]

[7] Tedlock. 113.

Blood Woman, the daughter of a lord named Blood Gatherer hears of the tree and goes to see it out of curiosity about the fruit of the tree. The head of One Hunahpu speaks to the maiden and assures her she doesn't want the fruit of the tree.
"I do want it", said the maiden.
"Very well. Stretch out your right hand here so I can see it," said the bone.
"Yes," said the maiden. She Stretched out her right hand, up there in front of the bone.
And then the bone spit out its saliva, which landed squarely in the hand of the maiden.
And then she looked in her hand, she inspected it right away, but the bone's saliva wasn't in her hand...
Right away something was generated in her belly, from the saliva alone, and this was the generation of Hunahpu and Xbalanque.[8]

Beyond the creation myth, the calabash tree was an extremely important tree for the ancient Maya. The gourds of the tree were often cleaned and elaborately decorated for food and water storage. The hard wood is also an excellent construction material.

Today, the gourds are used in many medicinal cures. One cure for whooping cough calls for splitting a ripe calabash in two with a saw blade and mixing the inside of the gourd with the fat of a chicken, the fat of an armadillo, and two heads of garlic. This mixture is then boiled together and made into a syrup that is mixed with honey.

CECROPIA
Cecropia peltata (Cecropieae)
Other Names: trumpet tree, guarumo, yaruma

Cecropia is a distinctive tree common to sunny, second-growth areas. Like the thorny acacia plants, Cecropia trees also have ant domintia, spaces specifically available for Azteca ants. In cecropia trees, these spaces are located in the trunk of the tree and can be easily identified by the trunk's noticeable rings. The ants protect the tree for other insects, mammals, and birds. The ants will also remove any vines growing in the tree. Such vines would otherwise compete with the tree for light.

Cecropia leaves were used by chicleros as a substitute for tabacco. Medicinally, the leaves are also used to treat rheumatism, sore throats, high blood pressure, diabetes, and other conditions.

CEIBA
Ceiba pentandra (Bombacaceae)
Other Names: kapoc, cotton tree

The Ceiba, the national tree of Belize, was considered as the Maya Sacred Tree of Life. The trees, which grown extremely tall, connect the earth to the sky. It is said that the ixtabi, the malevolent forest spirit, often frequents them at night.

The trunks of the Ceiba, especially of the younger Ceibas, are covered with spines which protect it from animals. Besides the spiny trunk, the tree also has characteristic seeds imbedded with a soft material known as "kapoc." Kapoc is traditionally used to make pillows, matresses, furniture, and life-vests. These seeds can also be used to make oil for soaps and lamps. The wood of the tree is often used to make canoes.

[8] Tedlock. 115.

CERICOTE
Cordia dodecandria (Boraginaceae)
Other Names: kopte'

Cericote is a slow growing hardwood tree. It has a beautiful wood with a Straight grain which is often used for carving and in making fine furniture. When it is flowering, wonderful orange blossom ignite the branches. The edible fruit is used to make jams and preserves.

CHICLE
Manilkara zapota (Sapotaceae)
Other Names: chico sapote, sapote, sapodilla

Chicle trees are often easily noticed in the forests of the area because of the criss-crossing slash marks which mark the trunk. These marks are not characteristic to the species but are made by chicle tappers as they harvest chicle, the original form of chewing gum, from the tree.

Chicle has been tapped from the trees since the time of the ancient Maya. In Belize, chicle was a primary export between the 1920s and the 1960s as a gum base for English and American chewing gum. Export declined, however, as the number of usable trees declined (chicle trees can be tapped only approximately every six years and only three times each).

The chicle tappers, chicleros, live in the forest in small groups for months during the rainy season in order to collect the chicle. To harvest chicle, the chicleros climb the trees and use a sharp machete to make zig-zag slashes in the outer bark of the tree. The latex, which drips from the cuts, is then collect and carried in bags lined with rubber from the rubber tree and taken where it is boiled. Once boiled, the chicle is formed into blocks and prepared for storage and shipment.

Chicle trees are also an important source of lumber for house construction. The brown fruits which look similar to a potato are often eaten by howler monkeys.

COCOYOL
Acrocomia belizensis (Palmae)
Other Names: Supa

Cocoyol is recognized by its criss-crossed bark pattern. The fruit of this palm is sometimes boiled in sugar to make a delicious treat. This candy is sold to school children in the area.

COLA DE FAISAN
Anthurium schlechtendalii (Araceae)
Other Names: pheasant's tail

Plaza Faisan, near the center of El Pilar's main cultural center, is named for this hearty ground plant. The inflorescence, sticking up amongst the large green leaves may remind you of a pheasant's tail, a bird frequently seen in the El Pilar Reserve and surrounding area.

Cola de faisan has many medicinal uses. For swollen tonsils, the leaves are mashed with sweet or liver oil and the mixture is heated and placed on the neck twice a day. The juice from the crushed leaves is placed on chicken pox to help dry out the sores. It is also reportedly used to treat infections of the female reproductive system, sprains, back spasms and aches, arthritis, and rheumatism.

COPAL
Protium copal (Burseraceae)
Other names: sak pom, pom, pomte

The use of copal in maya ceremonies can be seen as far back as the tale of the dawning of the first day in the Popul Vuh, an ancient Maya creation myth:

> "And here is the dawning and showing of the sun, moon and stars. And Jaguar Quitze, Jaguar Night, Mahucutah, and True Jaguar were overjoyed when they saw the daybringer. It came up first. It looked brilliant when it came up, since it was ahead of the sun.
>
> After that they unwrapped their copal incense, which came from the east, and there was triumph in their hearts when they unwrapped it. They gave their heartfelt thanks with three kinds at once:

Mixtam Copal is the name of the copal brought by Jaguar Quitze.
Cauiztan Copal, next, is the name of the copal brought by Jaguar Night.
Godly Copal, as the next one is called, was brought by Mahucutah.
The three of them had their copal, and this is what they burned as they incensed the direction of the rising sun. They were crying sweetly a they shook their burning copal, the precious copal."[9]

Copal incense is still burned in Maya ceremonies today. According to tradition, the copal resin is to be collected when the moon is full to insure that the resin can flow easily.

Medicine from copal is used to treat rheumatism, toothaches, and infections. It can also be placed over the entry wound of copal spines to remove them.

COROZO
Attalea cohune
Other Names: cohune

If you walk down the beginning of the water trail on the other side of the parking lot, you will see a small house with a corozo roof, a common use of this palm in many parts of the La Selva Maya. Roofing, however, is not the only use for this palm. In fact, nearly every part of this palm can be utilized in some fashion.

Corozo nuts can be roasted and added to food, and there oil can be extracted and used for cooking. The heart of the palm is also edible. The oil can be processed and used as a high-quality oil for machine parts. Activated charcoal can also be made from corozo. Many decorative items are made from corozo nuts. These include jewelry, small carvings, and napkin rings. When polished, the varying shades of brown on these nuts shells are quite beautiful.

CREOLE GAL
Alocasia macrohiza (Araceae)
Other Names: macal, carib gal, coco de monte, wild coco

Creole gal, not to be confused with the similarly looking macal which you can see in the distance, is a beautiful ornamental plant. It is used to treat insect bites, swollen joints, vericose veins, and skin conditions. For mosquito bites, it is combined with grease and applied to the area. Warm leaves are placed directly on swollen joints.

GRANDY BETTY
Cupania belizensis (Sapindaceae)
Other Names: grande betty, chac pom, palo de carbon

Grandy Betty is easily recognizable when in fruit. The fruits are a small green berry which dries and opens producing a small brown, flower-shaped shell around bright orange and black seeds. These seeds and brown capsules can be seen scattered on the forest floor near the end of the dry season.

The wood of this tree is occasionally used to make rafters and charcoal. It is also often used to make part of the marimba, a musical inStrument often used in Belize and the surrounding area.

The leaves are said to be used in herbal baths for Strains and swellings, and the bark is used in a tea for stomach ailments.

GUANACASTE
Enterobium cyclocarpus (Mimosaceae)
Other Names: pich, tubroos, ear-tree

Guanacaste is a common tree of the El Pilar Reserve Forest. This enormous tree, a monument to the larger forest which once stood in this area, shadows the forest garden, providing shade for the plants below and a home to many frogs, birds, and insects.

[9] Tedlock, Dennis. 1986. *Popul Vuh: The Mayan Book of the Dawn of Life.* New York: Simon and Schuster. 181.

Guanacaste are often left standing in pastures for their fruits, which are eaten by cattle, and for their light wood, which is often used to make canoes and wood paneling.

Known as ear-tree, this beautiful tree produces seed pods which curve like the shape of the ear. The seeds inside are a beautiful tan color with rings of darker shades of brown.

GUANO

Sabal morrisiana (Palmae)

Other Names: bay leaf, botan, sabal

Many of the roofs in Bullet Tree Falls and in other parts of Belize and Guatemala are made from guano. To make a roof, the durable leaves are placed over cross beams with approximately two-thirds of the leaf on top of the beam and one-third of the leaf under the beam.

Guano leaves can also be lashed together over poles to make a Stretcher in an emergency. In utilizing guano leaves for such purposes, however, care must be taken to remove only a few leaves from each plant so that the plant may survive. Today, the removal of all of the leaves is leading to the rapid loss of guano in the area.

The heart of palm of guano is edible. It is said that Catholics once ate this heart as a substitute for meat on religious holidays.

GUMBOLIMBO

Bursera simaruba (Simarubaceae)

Other Names: indio desnudo, jiote, choca, chic-chica, birch, tourist tree

The gumbolimbo tree is also known as the tourist tree because of its characteristic peeling, red bark, which looks similar to a sunburned tourist. Gumbolimbo has many medical uses, including the treatment of snakebites, skin infections, and flus. It is also utilized as a treatment for the painful burning caused by the resin of the che chem tree. In fact, the trees are said to often grown close to one another.

HELICONIA

Heliconia spp.

Other Names: lobster claw

Heliconias, related to bananas, are characteristic species of tropical forests. They grow in swamps, along waterways, and in secondary forest (forest which is regrowing after disturbance).

The bright red, yellow, and orange appendages of the plant, shaped like lobster claws, are called bracts. Each bract contains several flowers, often green or blue, which can occasionally be seen emerging out of their brightly colored shells. The bracts collect water and provide a habit for insect larvae and adults.

Heliconia flowers are pollinated by hummingbirds, the small birds often seen at the El Pilar Reserve. Hummingbirds are divided into hermits and non-hermits, and heliconias can be divided up into those pollinated by hermits and non-hermits. Non-hermits have short, Straight beaks and pollinate heliconia with short, Straight bracts (the part of the flower that looks like a vessel). Hermits have long, curved beaks and pollinate heliconia with curved bracts. The curve of the bract and the location of the pollen in the bract corresponds with a specific shape of hermit beak. This prevents cross-pollination (pollination of one species by another).

HOG PLUM

Spondias sp. (Anacardiaceae)

Other Names: jobo

Hog plum, produces fruit which, though not particularly flavorful, are well-liked by howler monkeys and tapirs. In some areas, the fruit pod is ground and mixed with sugar, chile, or salt.

This tree, like many trees in this area, is recognized by its sap which is a very sticky, white resin similar to glue.

The purple-yellow flowers of this tree are not ones that you would want on your kitchen table. They are bat-pollinated flowers which attract bats with an odor that smells like rotted food and dirty archaeologist's socks.

HUEVOS DE CABALLO
Stemmadenia donnell-smithii (Apocyanaceae)
Other Names: horse's balls, grandpa's balls, tonche', cojon, cojotone

Like many of the most common used and recognized plants in the region, people of the region recognize two species with the same name, huevos de caballo, and distinguish them as male or female. Traditionally, the two may have very similar characteristics, but the male plant produces smaller and fewer fruits. In this case, both species of Huevos de Caballo have fruits that grow on the tree in pairs. The hard, brown fruits, which are much larger on the female trees, when cracked open, have a orange meat inside which attracts numerous insects. The flowers of the male tree, unlike the fruits, are small and delicate white stars.

The white, milky latex of huevos de caballo can be used to kill botfly larvae. Botflies are insects which lay eggs on a specific species of mosquito. When the mosquito bites a mammal (including humans), it implants the egg on the host's skin, and the larvae quickly hatches and burrows down into the host's body, feeding until it is big enough to leave and pupate in the ground. As the botfly moves its spine-covered body around to eat, it can be quite uncomfortable for the unfortunate host. To get rid of this nuisance, the sticky huevos de caballo latex can be used to seal up the hole so that the larvae can not get air. When the larvae is dead, it can then be squeezed out.

HUEVOS DE CHUCHO
Thevetia ahouai (Apocyanaceae)
Other Names: huevos de perro, cojon de miko, dog's balls, ix akitz, ankitz, yellow oliander

This hard wood is used for fence posts and other construction needs. A medicine from the sap can be used to treat toothaches and skin sores. Like the closely relate huevos de caballo, , huevos de chucho can also be used to kill botfly larvae.

JICAMA
Pachrhizus erosus (Caesalpiniaceae)

Jicama is a vine that produces a large, brown tubor with a crunchy white inside. This root is pulled directly from the ground, sliced, and eaten raw in salads or alone. Jicama is sometimes planted alongside of corn in milpas.

Jicama, like the Guanacaste tree and many other plants in the forest garden is a legume. Legumes are an important part of the forest garden because of their association with *Rhizobium*, bacteria that live in their roots. These bacteria can take nitrogen in the air and fix it so that the legumes, as well as other plants in the forest garden, can use it.

IXCANAN / AXCANAN
Hamelia patens (Rubiaceae)
Other Names: axcanan, polly red head, red head, sanalo-todo

The Mayan name, ixcanan or axcanan, means 'guardian of the forest' This guardian can, in fact, be seen along the edges of the El Pilar road, protecting the reserve and its inhabitants. This shrub is used to treat skin irritations, menStrual cramps, and insect bites.

LENGUA DE PERRO
Psychotria tenufolia (Rubiaceae)
Other Names: dog's tongue, x'anal

Lengua de perro is considered to be the 'male' counterpart to Psychotria acuminata, the 'female.' This plant is used medicinally in herbal bath preparations to treat wounds, rashes, swelling, and nervousness. Lengua de perro leaves and flowers can also be applied directly to infected sores.

LENGUA DE VACA
Sanseuiena trifasciata (Agavaceae)
Other Names: cow's tongue, snake plant, culebrilla

Lengua de vaca has the look of many of its family with thick, succulent leaves, which aid water storage. The flowers of this plant are small, white, and wonderfully aromatic.

Lengua de vaca is best known as a snake bite remedy. In one preparation, the leaves are boiled in water and consumed as a tea. The number of leaves varies depending on how long it has been since the bite occurred. Once out of danger, the leaves are used as a laxative to remove all poison from the system. It is also said that the leaves of lengua de vaca can be chewed directly to treat both snake bites and diabetes.

MACAL
(Araceae)
Other Names: Coco

Macal, which looks similar to the creole gal which you saw earlier, is often in gardens surrounding homes in the El Pilar area. Many parts of the plant are edible. To prepare the root, boil it and peel it. Then, mash the root with water. The root is also steamed over meat and put in soups. The young leaves are also edible. Harvest the shoots and remove the main veins. Then, boil or fry the chopped leaves.

The Macal River, one of the largest rivers in Belize, is named after this plant. You may have seen this river if you traveled through San Ignacio on your way to El Pilar

MANAX
Psedolmedia oxyphyllaria (Moraceae)
Other Names: wild cherry, mountain cherry

This beautiful tree produces small red fruits, similar to other types of cherries, which are quite juicy and sweet. The wood is hard and often used for construction. A medicine to treat diarrhea can be made from the bark. Look for larger manax trees in the north plazas and in Plaza Manax itself.

NEGRITO
Simaruba glauca (Simarubaceae)
Other Names: dysentary bark, pa-sak, aceituno

Also called aceituno, which means olive, negrito has edible fruit which tastes much like an olive. The seeds of this fruit have an oil which can be used for making soap and in cooking.

The wood of negrito is said to be a good timber wood because it grows Straight. It is often used for house frames and broomsticks.

Medicinally, negrito is used to treat dysentary, diarrhea, internal bruising and bleeding, and stomach and bowel ailments.

PACAYA
Chamaedora pinnatifrons (Palmae)
Other Names: chi'iib

Palms are a frequently utilized resource in the La Selva Maya and in the tropics in general. Uses of palms include construction, roof thatching, oil for food and cleaning, clothing, brooms, and even napkin rings. This palm is well known for its edible young pods that taste similar to asparagus. They are boiled and the inside is removed and eaten.

PALO TINTO
Haematoxylam campechianum (Caesalpinaceae)
Other Names: logwood, palo de tinto, tinta, campeche

Though this tree does not grow large, it is an extremely important species in the history of Belize. Palo tinto has two prominent uses; it was once used frequently to produce dye and was, and still is, used for fence posts, building posts, and railings. When the wood is mashed and boiled, a blue dye can be extracted. Additives, including mahogany, can cause color variation. Because of this dye's versatility, palo tinto was the major timber export of British Honduras (now known as Belize) in the 18th century. Today, it has been replaced by man-made dyes.

One local says that the large guanacaste in the forest garden will help the palo tinto survive by drawing water into the area.

RAMON
Brosium alicaStrum (Moraceae)
Other Names: breadnut, copomo

In early April, you may see many small orange and red fruits scattered on some of the trails of El Pilar. These fruits, which look like oranges but taste similar to apricots, are ramon fruit. Though there is little flesh around the large nut inside, the sweet taste of these fruits attracts many animals. Howler monkeys, coatimundis, and other species of mammals have been seen having a ramon fruit snack at the reserve.

Humans use the fruits as well. The fruit can be boiled and ground into meal to make tortillas and bread (thus the name, breadnut). The fruit is also used for fodder.

RUBBER TREE
Castilla elastica (Burseraceae)
Other Names: hule, kikche, uule, ya

The rubber tree is said to have once been common in Belize before the large-scale use of the tree for rubber extraction. Though man-made rubber is now used today, the rubber is still used in many communities to make water-proof bags sometimes used for chicle collection.

The ancient Maya used the rubber to make balls used in a ceremonial ball game. A typical ball court can be seen near Plaza Copal.

The rubber tree is also used medicinally. For a Strained back, one can place the resin on a clean cloth and place it on the back. It acts like a plaster cast. Midwives are said to use this for mothers after birth.

The tree has a small, edible red fruit.

SPOONWOOD
Trichila havanensis (Meliaceae)
Other Names: palo de cuchara, limoncillo

As the name implies, spoonwood is a soft wood used to make spoons. It has a mottled red and white bark and small green berries with a sticky white sap. This is different than the limoncillo which is a hard wood and belongs to the citrus family.

SOUR SAP
Annona muricata (Annonaceae)
Other Names: guanabana, spiny custard apple

If you take a small piece of leaf off and crush it, you will notice the distinct smell which can help you identify this tree. The fruits, however, are its most noticeable feature; they are covered with huge spines!

STRANGLER FIG
Ficus spp. (Moraceae)
Other Names: matapalo

Strangler figs are common in and around the plazas of El Pilar. These trees actually start out as vines, whose seeds are dispersed by birds. The vines grow downwards from the upper branches of the trees. As the vine grows, it begins to surround the tree and competes for the light. Eventually the vine outcompetes the tree, leaving only the Strangler fig. The fig, because of its growth pattern, now looks similar to a tree. Many times, there is a cavity left where the originally tree has decomposed. This cavity provides a home for bats and other small mammals.

VANILLA ORCHID
Vanilla planifolia (Orchidaceae)
Other Names: vainilla

The vanilla orchid, with a sweet aroma and stout leaves, can be easily recognized along the trails of the forest garden. This orchid is said to have been used by the ancient Maya in a potion for revenge. If a woman felt slighted by a man, she would make a Strong perfume from the pods of the vanilla orchid, skunk vine root, balsam resin, and copal resin. While saying prayers, she would then place this perfume in a cloth bag hanging in the breeze so that the aroma would blow toward the man. The man would then be under her charms.

The orchid is also used medicinally. The seed pod of the vanilla orchid is used in remedies for stomach pains and puncture wounds. The leaves are used in a cure for female hair loss (sorry, it apparently does not work for males).

WIRE WIS
Lygodium venuStrum (Schizaeaceae)
Other Names: wire vine, bejuco de alhambre, xix-el-ba, alambre xiv

Wire wis, as it name implies, can be used for tying in replace of wire. It is also a medicinal plant which is considered a general coolant of the system. It can be used to treat skin fungus, rashes, sores, and headaches.

XATE
Geonoma sp. (Palmae)

Xate is a prized ornamental palm in Guatemala. It can be used to make paper and shampoo. Jade, another common palm is the region, is its male counterpart.

APPENDIX III: FOREST GARDEN LUMINOSITY

Notes on The Maya Forest Garden at Tzunu'un

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Proposed garden area

The area in which ground and lower canopy vegetation has been cleared around the buildings at Tzunu'un is approximately one half hectare (5,000 m^2). Of this area, about 1500 square meters are occupied by the buildings in the complex, leaving around 3,500 square meters of potential garden area. It is a bit hard to visualize how this might have been utilized, inasmuch as present construction activities and a modern road occupy portions of the area. Presumably the original extent of the property would have included what is now the road to within some distance from the small aguada, presently on the opposite side of the road. On the north side of the area, the additional clearing of this season reveals the cluster of buildings to the north, which indicates that the neighboring residential area would probably have used that land, conStraining Tzunu'un use to the current hypothesized area. The east and south limits are taken as the current cleared area, although presumably the area behind Structure 1 would have been more open and part of the use area. The available garden area at Tzunu'un fits well with the size of Maya household garden areas hypothesized by Sanders in "Classic Maya Settlement Patterns and Ethnographic Analogy" (.25 to .5 hectares).

Several assumptions have been made about the use areas into which the forest garden might be divided. These may not coincide with the building site drawings made by Paul Bailly, which show tentative plantings in some zones, notably near Structures 1 and 2. Current observed practice in Maya areas of Mexico is to have taller plantings at the rear and outer zones of the lot, with shorter plants, such as herbs and ornamentals, in areas closer to buildings, frequently in association with a swept dooryard area at the entrance to the main residence and also a swept area in work zones on other parts of the lot. It is unclear me what plantings might have been made in interior courtyard space by the Maya during the El Pilar time period. One assumption would be that at least some ornamental plantings might have been utilized, particularly in roofline drip zones, as seems to be a current practice, and that shade or fruit trees might occupy some corners

If a similar scheme is utilized for the forest garden at Tzunu'un, the current patterns of plantings would work reasonably well. At present, with the exception of several cohunes, particularly those near Structure 4, the area circumscribed by the forest garden path tends to be less shaded, and therefore better suited to plantings of sun-seeking plants, while the fringes of the lot tend to be more heavily wooded, containing the guanacaste, other cohunes and trees of substantial size and shade production. In these areas there are possibilities for interplanting shade-tolerant species among the trees.

Plants

Frederick M. Wiseman, in "The Agricultural and Historical Ecology of the Maya Lowlands", establishes hypothetical ratios of land use in his "artificial rain forest" as 28% trees, 40% shade-tolerant planting and 32% full sun areas. This appears similar to the present diStribution of available planting areas in the Tzunu'un plot, if the very open area to the east of Structures 1 and 2 is included, so these ratios will be used for Tzunu'un.

While Wiseman utilizes ramon as the food tree in his model created for the Petén, at El Pilar it would appear to make more sense to utilize a combination of trees already present in the garden area or on the site. Principal trees to encourage would be: aguacate(*Persea americana*), annona (*Annona cherimoya*), cohune (*Oribignya cohune*), copal, guanacaste, guayaba, papaya (*Carica papaya*) and ramon (*Brosium alicaStrum*). While it might be possible to cultivate cacao (*Theobroma cacao*), the available literature seems to indicate that it would do better in a moister environment with richer soil.

Shade-tolerant plants are typically classified as those utilizing from 500 to 4,000 foot-candles of light in order to produce successfully. Vanilla and malanga can grow with as little as 500 foot-candles; piña (*Ananas cosmosus*), cassava (manioc, *Manihot esculenta*) and macal (*Dioscura alata*) need a minimum of 1,000. Camote (sweet potato, *Ipomoca batatas*) requires 3,000 footcandles.

Plants requiring 4,000 or more foot-candles of light for twelve hours or so a day are: beans, chile, maize, and most squashes. Herbs such as achiote and epizote may be flexible in light needs, but seem to do better in sunnier locations.

A number of plants which could have been utilized in a forest garden are perennials. Among these are: cassava, jícama (yam bean, *Pachyrrhizus tuberosus*), malanga (*Xanthosoma violaceum*), sweet potato, yam (*dioscorea trifida*) and some peppers ("bird pepper", for example).

Productivity per square meter of these crops varies substantially. Beans are estimated by Wiseman, based on Cowgill, to yield 2.4 kilograms per square meter. Maize, on the other hand, is estimated to yield 1600 kilograms per hectare (Wiseman), 1200-2000 pounds per acre (Tzul) or approximately .16 kilogram per square meter. Other crops for which statistics are available yield: manioc .26 kg/m^2

squash	.74 kg/m^2
sweet potato	.66 kg/m^2
malanga	4.09 kg/m^2
jicama	.78 kg/m^2

Information on other potential cultigens is not currently available, but is assumed to be within these ranges. It is important to obtain information on the additional plants since they seem to be those which would produce better in the lower light areas than the traditional milpa crops.

Other considerations

If it is assumed that the forest garden would be in permanent cultivation, allowance would have to be made for restoring soil nutrients used by the annual plantings. Species of trees or legumes which fix nitrogen and other nutrients would have to be identified and planted, or alternative methods, such as use of household waste and night soil would need to be explored. On the other hand, the types of interplanting which occur in a forest garden would substantially reduce the problems of weed infestation which impair productivity of milpas in the second and subsequent years, and therefore interplanting would extend the feasible utilization period.

The role of the forest garden should be taken as supplemental to the milpa system, on which the population would presumably depend for the bulk of its carbohydrate and protein production, through annual plantings of maize, beans and possibly squashes. In addition, the forest garden can be utilized to produce special plants for medicinal and religious purposes. It is known that stingless bees were kept in Yucatecan house plots at the Conquest, but there is no information about practices at El Pilar.

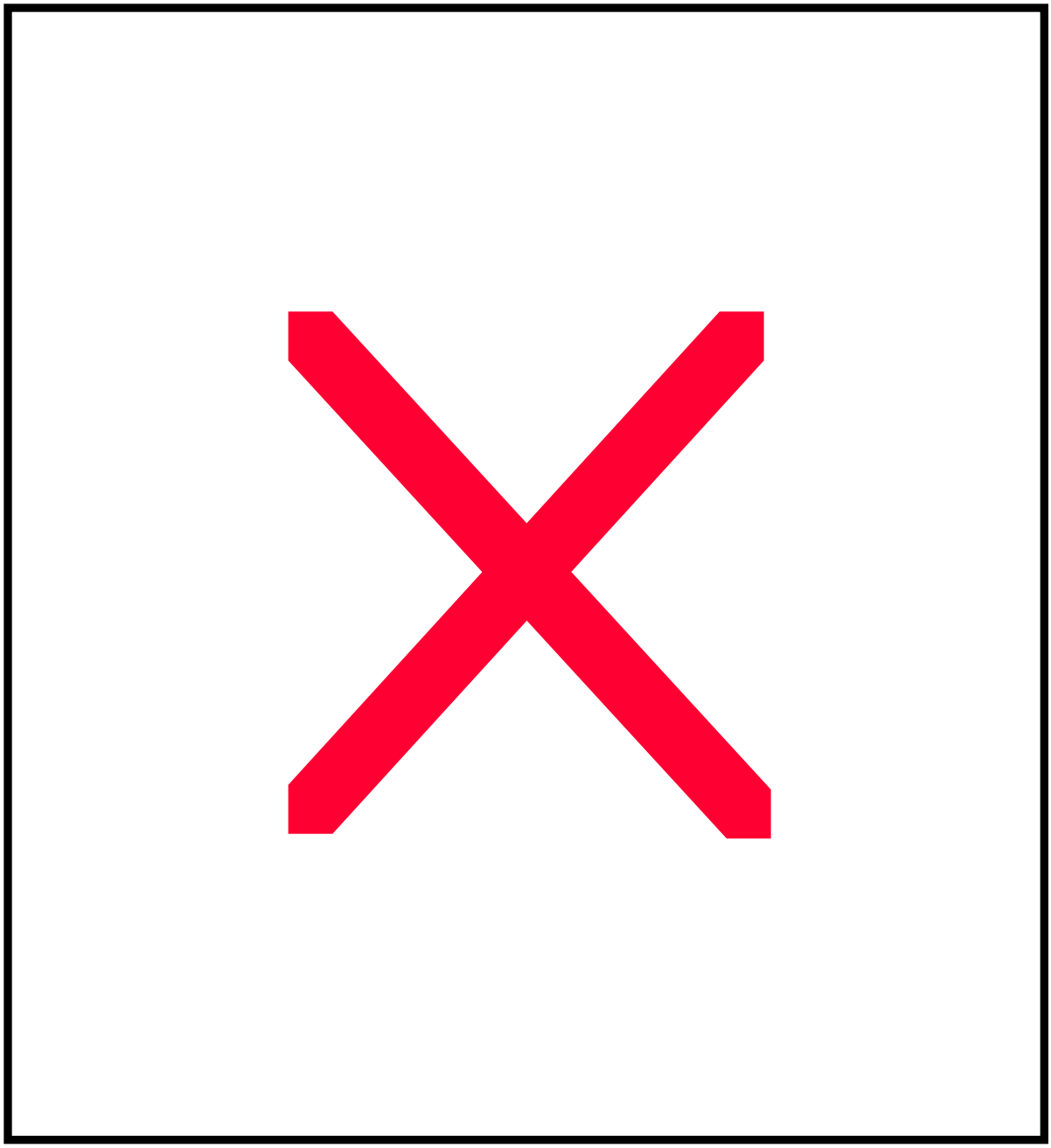
Foot-candle readings were collected in the forest garden area using a Gossen Luna Pro lightmeter operated in incident mode, and while positions were collected with a Trimble Pro XL GPS receiver. Carrier data were processed with Pathfinder Office and the data were exported to Surfer to create an isolumenosity map of the garden area.

The attached isolumenosity map shows the approximate areas of the Tzunu'un forest garden in which plants requiring particular light levels could be planted. It should be noted that light readings were taken close to mid-day in early June, but that intermittent cloud cover was present, reducing readings by 1-2 full steps in the sunniest areas. Actual planting should be planned on the basis of specific area circumscribing performed in full mid-day sun in order to create the most accurate and productive environment.

Suggested procedure

1. Using existing tree/plant inventory compiled by Nicole Gerardo, decide whether to expand planting areas or to utilize only existing spaces
2. Decide what plants to establish
3. Determine availability of transplants/young plants
4. Locate reliable waterer and water source during establishment period
5. Hire Don Heriberto Cocom to mark garden areas suitable for plantings and to decide which plants to put where
6. At beginning of rainy season, plant perennials and annuals (maize, if desired) which would have been planted at that time
7. Schedule maintenance watering to meet rainy season weekly deficiencies
8. If beans are desired first year, interplant in the maize or other areas in August (traditional local variety needs decreasing light period to blossom)
9. Maintain weekly watering through first dry season following planting and evaluate changes in plantings based on problems/successes encountered

Submitted 30 August 1999



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Luminosity study of the forest garden area

S. Hayes conducted a study of the luminosity of the area of the forest garden. Light readings were taken with a Gossen Luna Pro light meter set in incident mode. The positions of the light readings were recorded with the GPS equipment for code correction only. Not only does the degree of cover in the forest garden area preclude carrier correction, but the nature of the study did not require precision greater than sub-meter. The Luna Pro displays data in exposure values. This is a power of two scale of use to photographers. The correlation between exposure values and foot-candles in the relevant portion of the scale is given in the table below.

Exposure Value	Foot-candles
14	130
15	260
16	500
17	1000
18	2000
19	4000
20	8000
21	16000

Light readings were taken in the middle of two days. The data was collected at the beginning of the rainy season in the area. Periods of clear sky were actively sought for data acquisition but on both occasions there was some intermittent cloud cover. It should thus be recognized that some of the variability in the data is due to variability in sunlight and is not solely the result of the degree of cover. The data on both days covered much of the same area and the data on the second day was adjusted by a multiplier consisting of the mean of the first day's data divided by the mean of the second day's data in order to create comparable data sets. The data set itself is in the report of S. Hayes.

Appendix IV: Integration Links between the GIS data and the other data
Anne Girardin

The GIS cannot readily integrate data like sketch maps, field reports, artifacts Excel files, architectural pictures. Links have to be created between the GIS and those data to have a complete system among all the data. The GIS data on the artifacts can be automatically integrated in the Excel files for the statistics.

The excavations can be linked to the sites and settlement sketch maps with a CAD format, where hand sketch map drawn on the field are scanned, the field report comments recorded in text (.txt) format and the digital pictures taken during the excavations maintained as jpeg or tiff format.

It would be very challenging to create the relational model among all the data collected in El Pilar.

The archaeological survey and excavation data collection require a survey planning base and a set of equipment. The following tables outline the required platform.

Method of survey

	Maya settlements	**Architectural features**	**Artifacts**
Georeferencing	3 inter-visible GPS control points	Control points	UTM 2*2 grid
Method	Carrier mode processing: 45min Differential correction	GPS with carrier mode processing Or TerreStrial survey with least square adjustment	GPS or terreStrial set up from control points
Accuracy	< 10cm	< 10cm	10cm
Survey	Total station	Total station	Laptop
Draw	GIS / CAD	CAD	GIS
Accuracy	10cm	10cm	The unit

Appendix V: The LDF Chert Site ~ El Pilar

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QUARRY EVIDENCE AT EL PILAR

I. The quarry on the hill
- Borrow pit for excavation of chert raw materials
- Large broken hammerstones on surface
- Evidence of raw material testing
  1. broken biface blanks
  2. tests reflecting material rejects

II. Raw Material concentrations
- Relationship of raw material to production process
- Evidence of use of fire in processing
- Document technology
- Experiment with petrography
- Dating related to ceramic evidence

III. Area conducive to experimentation in quarrying
- Extracting raw materials
- Prepare cores and biface blanks
- Quantify production sequence
- Identify production types

BIFACE PRODUCTION

I. Identify production techniques
- hard hammer sequence
- soft hammer evidence
- blade production

II. Evidence of secondary processing
- Procurement labor division
- Biface production specialization
- production of flakes
- Nature and skill of production Strategy

TYPES AND FUNCTIONS

I. Types and Uses
- A. Grinding on bifaces
  - 1. Prepared by grinding
  - 3. 2. Use of pestles of metates?
  - Tasks appropriate for different biface types
- B. Knives for cutting
  - 1. grasses
  - 2. roof thatching
  - 3. meat

II. What activities are represented in collections?
- A. wood
- B. antler
- C. hide
- D. plant
- E. meat

III. Use of short-term tools of flakes widespread
- A. Generalized uses?
- B. Special objectives?

III. How do Lithic and Ceramic technologies compare?
- A. Basic Household Inventories
- B. Integrated and complementary