CHAPTER 4

FIELD STRATEGY AND ANALYSIS PROCEDURES

This chapter describes the procedures of the research: (1) the sampling survey strategy used for the two areas of Cochabamba; (2) the definition of the size of archaeological site, and the calculation of occupational areas by period; (3) the statistical analysis conducted with the land use data collected; and (4) the information provided by the ceramic material obtained from the surface collections. The objective of this research was designed to generate regional data to assess diachronic changes in human-land relationships. A random sampling survey strategy was adopted to study the regional distribution and location of settlements and its relationship to soil productivity in each area of research.

Regional settlement survey has long been recognized as a powerful tool for investigating how prehistoric peoples settled a region, exploited resources, and managed their surrounding territories (Adams and Nissen 1972; Blanton et al. 1981, 1982; Drennan et al. 1985, 1991; Flannery 1976; Kowalewski 1990; O'Brien and Lewarch 1992; Parsons 1974; Steponaitis 1978; Trigger 1968; Willey 1953; Wilson 1988).

Objectives of the field strategy

The settlement survey in this research had two major objectives: (1) recording the spatial distribution of settlements in relationship to particular topographic and soil zones; and (2) comparing settlement distribution by period against agricultural productivity in areas of different soil productivity, and different topographic setting. Two research areas were chosen for the survey procedure. Comparison of the density of occupation of settlement by period in relation to topographic zones, and soil group zones, allows us to determine whether settlement locations were chosen to promote agricultural production.

This research assumes that current data on soil classification for defining soil productivity can provide a relative measure of prehistoric productivity. This assumes similar soil qualities in the past (Kirkby 1976; Kowalewski 1982; Nicholas 1989; Sanders and Nichols 1988). I have not attempted to estimate potential populations for comparison with archaeological populations.

Two arguments relating to the relationship between agricultural productivity and site location guide this investigation. First, at the large scale, the more productive soils in a given region should have a denser occupation. This leads our working hypothesis that Tiwanaku style remains should correlate positively with potential agricultural productivity.

A second assumption, at a smaller spatial scale, is that there should be, if not a one-to-one correlation of best soils and individual settlement location, at least a close spatial relationship between each.

Thus, settlement **near** good soils is as important as settlement **on** goods soils --representing a village catchment area. Actual correlation of settlement and soils will depend on the density of the settlement, the spacing of habitational compounds, availability of good productive soils adjacent to settlements, and the variation of soil types in and surrounding the settlement. In this research, because settlements seldom occupy complete survey quadrats, and because in most cases the soils surrounding the survey quadrat are of the same class as the quadrat soil, the analysis will be limited to the correlation of settlement and soil quality in each of the sampled survey quadrats.

It is unknown at this point if the scale of each of the survey area will allow reconstruction of individual "regional systems" or a Cochabamba-scale system, in each of the chronological periods (see below for the limitations provided by the survey strategy itself). Assuming that land use and settlement patterns in the two survey areas are part of a same Cochabamba regional system will only confuse the objective of monitoring variation in those patterns in the Formative and Early Intermediate Period. There are differences in Formative ceramics between the two survey areas, whereas there is a common occurrence of Tupuraya style materials for the Early Intermediate Period.

The common stylistic assemblages to the two survey areas cannot be interpreted as evidence for an integrated political system in Cochabamba. Instead, assuming smaller political units, restricted to each survey area, provides a more useful approach for distinguishing the differences between populations using similar assemblages. In other words, for analytical purposes, I will assume the existence of independent settlement systems despite what may or may not be suggested by the regional distribution of particular ceramic styles.

Settlement survey methodologies: a review

The scale of sampling and total coverage surveys affects the distinguishing of spatial patterns. Discernment of spatial patterns depend on the scale of the comparison, such as a portion of a valley, a complete valley, or at a multivalley regional scale (Ebert 1993; Johnson 1977, 1981; Kowalewski at al. 1983; Nicholas 1989:466; Paynter 1983).

The random sampling survey strategy adopted for this research aimed at providing a large and robust database on an extensive spatial scale in two survey areas. This strategy allows relational assessment of soils types and occupation density in order to monitor human-land diachronic relationships and environmental context of human occupation.

Whether to sample a large area, or fully cover a smaller one, is a very important issue for the archaeological researcher (Kintigh 1990:239; Whalen 1990). A sampling survey totalling 20 km^2 is a more time consuming strategy than surveying a contiguous area of 20 km^2 in a 100% coverage survey strategy. For the objectives of this research, the ideal strategy was one that would generate a large-scale picture of the range of diversity in settlement location and differences in the soil productivity.

My sampling strategy could not produce data to reconstruct, for example, site typologies and settlement hierarchies (Crumley 1976, 1979; Evans and Gould 1982; Flannery and Marcus 1983; Johnson 1981; Steponaitis 1981). Nor does it allow nearest-neighbor spatial analysis. Total coverage surveys are the ideal strategy to gather data for these purposes1. However, issues of settlement dispersion, hierarchies, inter-site distances, or overall distribution patterns, are not critical to the questions posed in this research. The information that *is* critical deals with the relationship between settlement and environmental characteristics relating to agricultural production.

The limitations of surface survey, in general, have been well noted in numerous contributions on archaeological survey (Ammerman 1981; Binford 1964, 1992; Hole 1980; Parsons 1990; Plog 1986, 1990b; Plog, Plog and Wait 1978; Read 1986; Schiffer et al. 1978). Parsons (1972; see also Wandsnider and Camilli 1992) notes that surface reconnaissance cannot hope to provide a full picture of occupation, since many sites may be buried or disturbed. This makes it challenging to assess site

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1 Sampling data, however, can be used for measuring settlement dispersion using Morisita's index of dispersion, which needs data on site frequency per contiguous or non-contiguous sample units (Shennan 1991:324).

size using surface evidence, using recorded sites to estimate density of occupation, and using surface sherd density to make demographic estimates. Despite these problems, survey research has provided important insights on the evolution of settlement patterns in many regions (Adams 1972; Blanton et al. 1982; Kowalewski et al. 1989; Sanders et. al 1979; Schreiber 1992; Wilson 1985). Even if, as Parsons suggests, survey results are biased samples of original settlement patterns, and site size estimations and population estimations based on sherd densities are inaccurate parameters, archaeological settlement patterns serve as essential lines of evidence for studying settlement evolution.

Other limitations of regional survey relate to the usefulness of "partial" information, the definition of size and shape of the survey units (Sanders at al. 1979: appendix E; Plog 1976), and the statistical limitations of probabilistic survey methods (Nance 1986). However, many of these issues also affect "total" coverage strategies; both require making choices concerning intensity of coverage, team size, etc., thus precluding in most cases obtaining true "total coverage" results.

Finally, the potential that a sampling strategy will miss the most important site(s) in the survey area, and therefore skew the interpretations made with the sample, has sometimes been used as an argument against sampling. As much as this is a real possibility, sampling strategies are not designed or intended to find low density or uncommon site types --the "Teotihuacan" cases-- such as regional centers. Nor are they designed to provide information on the total range of settlements in each area. In my research, this survey was designed to assess the relationship between agricultural potential and the most *common* site types (villages and homesteads).

Random sampling survey strategy

My research goals entailed: (1) getting large-scale spatial coverage; (2) being able to place sites in a relative chronology; and (3) generating comparable data sets from two areas.

The comparative analysis of two areas of the region was needed to assess potential differences in occupation on agricultural areas in the Intermediate Period, when Tiwanaku style materials are the dominant decorated pottery style in both survey areas. At the smaller scale, comparison allows us to discern similarities and differences in land use patterns through time among each region. The land use and settlement patterns in the Tiwanaku Intermediate Period can thus be contrasted with the settlement patterns for the Formative and Early Intermediate Period in each region.

Identical survey strategies were conducted in both areas in order to have two sets of fully comparable settlement data (Appendices A and B). This provided an adequate dataset for making general inferences about a larger universe using statistical measurements on a controlled sample. The large number of "observations" provided by this sampling strategy (vs. one observable sample unit in a 100% coverage survey of a smaller area) helps to narrow the error range of the estimates (and interpretations) based on the population sampled.

Terminology

Several terms used in this dissertation must be defined. Survey quadrats are the 250x250 m square units into which the survey area was divided. A sample of these quadrats was randomly drawn for research (Figure 23 and 24). The complete area of each quadrat was surveyed in order to obtain the sample of sites for the analysis. A site was any cultural remains on the surface, either sherds or architectural features. The dimensions of each site were defined by the spatial dispersion of surface materials. Lot collections are surface pottery samples obtained either randomly or judgmentally from a site. Isolated scatters of sherds (with less that 10 sherds) were recorded as off-site lot collections, not as sites.

Number of sites is not simply the count of sites. Instead, it is the sum of the site fractions, or the fraction of each site that falls within the boundaries of the survey quadrat. The fraction is thus determined by the total area of the site recorded in the survey. For example, Figure 23 shows the distribution of sites and survey quadrats in the Capinota-Parotani survey area; the complete area of the 49 sites is presented, but not all of each 49 sites fell within a quadrat. If a site lay completely within a quadrat and another site has one third of its area within the quadrat, the number of sites is 1.3 sites (Appendices C and D: part 2). The actual count of sites recorded (i.e.,

49) is not used in the analysis. Rather I use the site fraction within the survey quadrat to determine the occupation area by period. This procedure complies with the goal of sampling to analyze strictly what is recorded in the sample and obtain measurable variation of the objects sampled.

Occupation by style or period, based on the presence of a pottery style or assemblage, refers to a single temporal component in a site, e.g., the Tiwanaku style occupation of site MI 13. Therefore, multicomponent sites have several occupations. Definition of the occupation area by period is based on the presence of pottery styles in the lot collection and in the area of the lot collection within the survey quadrat. For example, if the Tupuraya style is present in five of seven collections in a site, and the site covers 4 ha within the survey quadrat, the estimated size of the Early Intermediate Period occupation is 2.85 ha. This procedure takes into account the reality that occupation often continues on the same spots, and, yet, at the same time, that different occupations can occupy different areas within a site.

Survey procedures

I arbitrarily decided on a survey area of 200 km^2 in order to provide an area in which the sampling units could be widely distributed. Further, I wanted each area to encompass a portion of a river drainage and to include different topographic units (i.e., alluvial, piedmont, and mountain zones). As described in Chapter 3, the mountain ranges that separate drainages naturally define the boundaries and shape of the 200 km^2 survey: a linear and long river valley for Capinota-Parotani, and a circular basin with a confluence of rivers for the Mizque area.

Despite some general expectations as to distribution of settlement in each area (for example, that settlements are likely to have been located along water sources like rivers or seasonally watered quebradas) the survey area by design included lands outside the alluvial zone to provide a complete picture of regional settlement distribution.

Definition of the sample size

A north-south oriented 250x250 m grid divided each survey area into 6.25 ha. square units. The size of the survey quadrat was defined after a preliminary assessment of average site size in the survey areas.

The small size of the quadrat ensured a large sample, widely distributed throughout the survey area. In essence, a larger number of quadrats will produce more accurate error ranges for the estimates of total site population and for the estimated occupation area period than less quadrats. In fact, more important than quadrat size, is the number of quadrats required for survey. This figure depended directly on the parameters that set the sample size (see below).

The size of the survey quadrat did not insure the complete inclusion of each recorded site within the quadrat boundaries. This "edge effect", where the site extends beyond the boundaries of the survey quadrat, is reduced in larger quadrats where less doubts occur about the proportion of the site included in the quadrat area (Schiffer et al. 1978). The assessment that most sites are smaller than the size of the quadrat was accurate; 70% of the sites recorded in both areas were smaller than the survey quadrat. Not all of each site, however, lay within the survey quadrat. If a site exceeded the arbitrary boundaries of the survey quadrat, the total dimension of the site was determined. However, as explained above, only the fraction of the site within the survey quadrat boundaries was used for number of sites and occupation area figures; this procedure reduces the "edge effect" caused by the occurrence of a site in only a portion of the survey quadrat (Nance 1985:349).

The size of the sample to be drawn from each 200 km^2 survey area (i.e., how many survey quadrats to be surveyed in each area) was established through previous data (CUMAT-Pereira 1991) and personal observations in both survey areas. Given an estimated site density of 3 sites per km^2, and an estimated standard deviation 1.5 sites, I wanted an error range of not more than .5 sites at the 99% confidence level2.

From this calculation, I concluded that a sample of 60 sites was needed to make estimations of density and size with a 99% confidence level. By using relatively small quadrats of 250x250 m, that is 6.25 ha, I expected to find .1875 sites per survey quadrat. Therefore, the survey

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2 ó = 1.5 sites per km^2; t = 2.576 (p=.01; df=~); ER = .5 sites

needed to cover 318.5 survey quadrats in each research area. This number was rounded up to 320 survey quadrats, making a total area of 2000 ha, that is 20.00 km² (or 10.0%) of the 200 km² survey area.

An interesting methodological observation could be made at the conclusion of the surveys. Neither survey procedure recorded the required 60 sites --calculated as the sum of the fractions of sites with the quadrat sample-- needed to assess settlement spatial distribution at the confidence level I had set. Instead, 35.05 sites were recorded in the Capinota-Parotani survey area, and 18.22 sites in the Mizque survey area. The difference between the number of sites expected from the sample and the number found is largely a consequence of my inaccurate prediction of site density in the research areas.

Survey procedures

A simple random drawing selected the 320 survey quadrats in each survey area. The survey was conducted with plates prepared from 1:20,000 scale aerial photographs and with 1:50,000 scale topographic maps from the Bolivian Instituto Geográfico Militar. An accurate plotting of survey quadrats and sites on the plates was made possible by the aerial photographs that showed topographical features, such as streams, **quedradas** or hills, or the railway. The lack of 1:10,000 scale maps for both research areas and an incomplete set of aerial photographs for the southern half of the Capinota-Parotani survey area presented a few problems. The location of sites and/or artifacts concentrations was double-checked in the field with the aerial photographs and 1:50,000 topographic maps.

Sites recorded were numbered consecutively with a prefix CP and MI for the Capinota-Parotani and Mizque survey areas, respectively. The survey was conducted by two teams of five persons covering each one .0625 km^2 survey quadrat at a time. Once the southwest corner of the survey quadrat was located with help of the aerial photographs or maps, a compass helped to orient the boundaries of the quadrat. There is surely a margin of error in the location of the first corner of the survey quadrat. The variation in distance from the real point is difficult to calculate. But since every single quadrat was located with the same method, that variation should apply to each quadrat surveyed.

The members of the team walked in parallel strips, 30-40 m apart (i.e., survey intensity), following the natural contour of the topography. Steep slopes and eroded quebrada walls of survey quadrats were actually not walked as intensively as the flat terrain and low and medium slopes. These areas with geological disturbances and/or abrupt topography have a low probability of having been areas of prehistoric settlement; and even if this assumption is incorrect, these sites would have been obliterated by erosion. Although surveys were conducted during the dry season, spinous vegetation was a factor in slowing down the pace of the survey teams. Highly vegetated areas were surveyed when they were not located on the steep slopes, crevasses or quebradas.

All the survey quadrats selected in the sample were surveyed without major difficulties with the small-scale land owners (cf. Mathews 1992). Nor did any sample quadrats have to be replaced due to lack of access. Additionally, the survey period coincided with the initial agricultural tasks of the modern population, and therefore less interaction with local people occurred. By the end of the survey period in the Capinota-Parotani survey area (early December), extensive plowing and cultivation had obliterated inland paths that had previously allowed us to reach inland survey quadrats. Plowing activities only disrupted a couple of the last days of the survey season.

Finally, the survey strategy adopted an informal inspection of areas which were not in the sample of survey quadrats, particularly when the teams walked to the quadrats selected for survey. The same data was recorded for these inter-quadrat sites --2 sites were recorded in the Capinota-Parotani survey area, and 16 in the Mizque survey area. However, these additional sites will not be used for the analysis performed in the next chapters.

Spatial analysis of settlement and soil patterns

Settlement study of each period in each survey area entailed: (1) measuring the total site area, and area of site within the survey quadrat, based on the size of the surface scatter and architectural features; (2) obtaining surface lot collections to assess the site occupation by period based on pottery styles (Figures 25-30); (3) recording vegetation, topography, and size of soil types in each survey quadrat, and whether or not a human occupation was present (Dunnell and Dancey 1983; Appendices E and F); and (4) recording architectural and agricultural features (i.e., terracing and canals; Appendices C and D: part 1). The degree of disturbance produced by modern plowing, looting, and slope erosion was also recorded.

The above survey information was critical to identifying, measuring, and estimating total occupational area for the three soil groups and topographic zones by period for each survey area (Tables 5-7). The central analysis lay in determining if they were: (1) significant differences in the settlement population by period of each survey zone, with a larger occupation occurring in the most favorable agricultural area, especially during the Intermediate Period; (2) preferences for settling in particular topographic or soil group zone within each survey area; (3) changes through time in the total estimated occupation area or in the percentage of occupation of each topographic and soil group zone.

The percentage of occupation by topographic and by soil zone is central to the identification of settlement preferences. This is analyzed using the percentage of occupation of each topographic and soil zone individually, and not the occupation distribution among the three topographic or soil zones. In a random pattern, with no intentional focus on any particular zone, we expect that the occupation distribution would be proportional to the area of each zone (e.g., if the piedmont zone makes up 50% of the area it is expected that 50% of the occupational area will be in that zone). My research aimed at noting departures from such random patterns. The preferred zone would be the zone with the highest percentage of its area occupied, with respect to the other two zones.

Identifying significant synchronic and diachronic differences between and within zones and periods is aided by the graphic comparison of the means and error ranges at a 95% confidence level. These graphs reveal whether the differences between the samples are the result of random variation in the samples or if they are the product of significant (i.e., preferential) variation in the occupation area, or percentage of occupation by zones.

These statistical analyses answer the question of whether settlement patterns in the Formative, Early Intermediate, Intermediate, and Late periods can be "explained" by the same factors, such as a preference for settling the most productive soils.

Surface collections and ceramic analysis methodology Random and judgmental surface artifact collections were made at each recorded site. Random collections were conducted in those sites that: (1) presented (after a careful inspection of the surface remains) multi-component occupations; and (2) had a high density (>15 sherds/m^2) of sherds on the surface. Judgmental collections were conducted in site that: (1) had a very low density (<15 sherds/m^2) of sherds on surface; and (2) presented a single occupation. Some sites required both types of collections. Lot collections were not limited to the portion of the site within the survey quadrat.

The random collection units consisted of circular areas of 2.5 m radius (21 m^2) randomly placed within the site. All ceramic fragments and other artifacts were collected in these randomly located circles. Judgmental collections were made from the diagnostic surface remains found in different sectors of the sites.

The ceramic analysis of each lot consisted of: (1) documenting the proportions of each pottery style (Appendices C and D: part 7); (2) defining the occupation area by period based on the fraction of the site area within the survey quadrat; and (3) mapping the spatial distribution of stylistic components to reconstruct the location of settlement by period. Full analysis of pottery types was limited to the Tiwanaku style materials and was made to compare the assemblages of both survey areas.

In many cases the analysis of collections produced some "unidentified" material, mostly utilitarian pottery. The reliability of surface materials for dating sites thus varied. As a result, occupations characterized by less decorated pottery would tend to be underrepresented, as are deeply buried sites.

The spatial distribution of each pottery style was mapped by period by using the lot collection in which it occurred. However, the total area of the lot collection does not represent the occupation area. Occupation area, as noted earlier, are based on the areas of site falling within the survey quadrat (Figures 31-39).

The sites and lot collections of a sampling strategy represent but a portion of the original prehistoric occupation. Therefore, I have included in every map an indication of the sample of quadrats surveyed. In addition, comparing the settlement and style distribution maps by period inevitably generate a picture of "punctuated" change, not capturing gradual stages of site occupation and abandonment (Dewar 1991; Ammerman 1981:77).