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USE OF SPATIAL AND SPECTRAL SIGNATURES OF THE MARANPAMPA SITE, PERU IN ARCHAEOLOGICAL EXPLORATION

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ABSTRACT

The spatial and spectral signatures of the Maranpampa archaeological site were determined and used to locate other major sites in the vicinity of the Machu Picchu Ruins, Peru. This study employed both 8-bit scanned monochrome and Landsat multispectral data. One test site was explored on the ground, which is located 15 Km. Southwest of Machu Picchu along the Aobamba River. This site is a large agricultural production settlement. It is reported for the first time in this report. The spectral signature found is a result of both the geomorphological and vegetation cover of large alluvial terraces. The later contributes more than the former. It is possible to determine the location of the spatial distribution of structures as well as their building elements by taking image profiles. Density slicing and supervised classification are very useful in archaeological exploration.

1. INTRODUCTION

The Maranpampa archaeological site was preliminarily located in 1985 while taking a course in remote sensing of the environment (Chohfi 1985). The location of this archaeological site was the result of careful study and mapping of different signatures found in a few aerial photographs of SAN's 8485 project of 1956. Maranpampa distinguished itself from the surrounding environment by a series of trees growing in a straight line and several other rectilinear signatures. These signatures indicated that a potential archaeological site was found, perhaps consisting of buildings and agricultural terraces. Ground survey of a small portion of the entire area was carried out in 1986 and revealed the existence of a large archaeological site, which was later named Maranpampa (Chohfi 1986, 1987). The exploration was limited to only less than 10% of the site shown in the aerial photograph number SAN 8485-2046. The drawing on the right is by Poma de Ayala (1936), who left us with a great deal of information on the life of the people of the Tawantinsuyo. His drawings portrait many traditions of pre-Hispanic Andean life, which continued for sometime during the first few years of the Spanish Conquest.

The finding of such large unmapped archaeological site encouraged me to pursue a study on the capabilities of digital image processing of remote sensing data for further archaeological exploration and survey in the Machu Picchu Region. This research papers reports the results of such study. First, it presents the digital spatial and spectral signatures determined for Maranpampa. Second, it shows how the spectral signature was used to locate additional unmapped large archaeological sites employing TM/Landsat and principal component data in the same region.

2. SITE OF STUDY

The Maranpampa archaeological site also falls within the Machu Picchu Region. It is located only 2.0 Km (1.2 mi) Northeast of the Machu Picchu ruins (Fig. 1).

The terrain is fairly leveled with altitude ranging from 1,800 to 2,000 meters and covering an area of approximately 500 by 600 meters (0.3 Km^2). There are two perenial streams and shear cliffs that bound the site on the East and West, and Southwest, respectively. The vegetation cover corresponds to an abandoned tea plantation with sporadic presence of a secondary or tertiary replacement community of the original *ceja-de-la-montaña* forest.

A maximum likelihood supervised classification was conducted over a region of about 3,000 Km^2 of the Central Andes of Southern Peru.

3. DATA, METHODOLOGY AND MATERIALS

The majority of the data used in this research was described in the first report by the author, with one exception. That is, the aerial photograph employed in this case was number SAN 8485-2046.

The methodology is basically the same as the one in the first report. Moreover, the original methodology used with analog data to locate Maranpampa is found in earlier reports (Chohfi 1985, 1987).

The material changed from those mentioned in the first report because field work survey was carried out at Maranpampa, and at a test site along the Aobamba River later. The field work survey was conducted with traditional exploration equipment found locally, since the vegetation cover is high but not very dense and penetrable.

4. RESULTS

An 8-bit 4096x4096 pixels image was generated by scanning a 20 x 20 cm of a monochrome analog image, which contained the area of the Maranpampa site. It was a 5x partial enlargement of the SAN 8485-2046 aerial photograph. The scanning resolution was 0.49 μm. The digital image pixel ground resolution was equal to 0.25 meters. Its histogram is plotted in Figure 2 and statistical data is listed in Table 1.

Image processing techniques were applied to the above-mentioned 8-bit image to try to detect spatial signatures of the structures which were believed to exist under the vegetation. The spatial signatures were successfully determined by using high pass filtering followed by contrast stretch, image segmentation, and pseudo color generation. The reader should refer to the first report for the values used with these techniques.

The results show that Maranpampa is surrounded by an outer massive wall with rectangular structures and wide terraces on the inside. It should be pointed out that this site is mostly buried under a soil layer, which was formed by deposition of sediment from the hills above the main site area. The spatial signatures detected are due to the DN value of the vegetation growing on walls or on the location of buried structures. Low DN values correspond to the location of walls and the high ones are open areas. Therefore, the vegetation grows in such a way that it outlines the boundaries of many structures. These boundaries are easily detected due their DN values. Image profiles of selected structures are plotted in Figure 2, with arrows pointing to the location of walls. Additional profiles are presented during the symposium.

The stastistical data of the TM Landsat raw data and principal components of Maranpampa are graphed in Figures 3-5 and listed in Table 1. The TM/Landsat bands 4 and 7, and the first principal component of the TM data were used to conduct a supervised classification using the Maranpampa spectral signatures to locate additional archaeological sites. Moreover, a test site was selected which had similar gray tone and geomorphological characteristics as the Maranpampa training site. All pixels were classsified in the test site. Its spectral signatures were fairly identical to the ones of the training site.

Field work was conducted at the location of the test site along the Aobamba River in 1987 and verified the location of a large not previously mapped archaeological site. It is reported for the first time here. The site has a very rich cultural deposit. The following was found during the ground reconnaissance pottery sherds densely scattered throughout the site, mortars and grinding stones, remains of rectangular structures, retaining and terracing walls, quarrying area, and man-made granite blocks. The Quispi and Palacios families were farming a small portion of the site. The slides taken at the site are shown during the symposium.

The result of the maximum likelihood supervised classification shows the location of several such sites, which were confirmed by inspecting their signatures in the higher resolution aerial photographs of the same areas. The author believes it to be unnecessary to conduct ground survey of every single one of these sites. The spectral signatures are pretty well isolated and the test site yielded great results. The geomorphological characteristics and vegetation cover are the elements contributing for their unique spectral signature. The former less than the later. These sites are located at large alluvial terraces found at different altitudes, which have leveled land with good water source suitable for agricultural production sites.

5. CONCLUSIONS

The spatial and spectral signatures of Maranpampa were determined and successfully used to locate other large archaeological sites in the region of study. The spatial signatures allow for the study of the location of structures as well as the elements which make them up, such as walls, doors, outdoors and indoors spaces, and etc. The archaeological sites studied were found at large alluvial terraces located at different elevations. These terraces were suitable for the development of large agricultural production sites.

A test site consisted of another large archaeological site which is reported here for the first time. This site is located about 15 Km Southwest of Machu Picchu along the Aobamba. It is mostly a large agricultural production settlement, with an area of about 0.25 Km^2 The Machu Picchu Ruins covers only approximately 0.14 Km^2

The results of this and the previous report clearly show that exploring from above is more efficient, accurate, cheaper, and less time consuming than search on the ground below. One knows exactly where to go on the ground after analyzing the type of data employed here. It is worthwhile mentioning that there have been at least five archaeological expeditions in the region (Bingham 1930, Fejos 1944, Savoy 1970, Drew and Kendall 1981, 1982) that missed the site reported and many others due to the fact that they were searching on the ground only.

The general methodological conclusions of the previous report apply here too.

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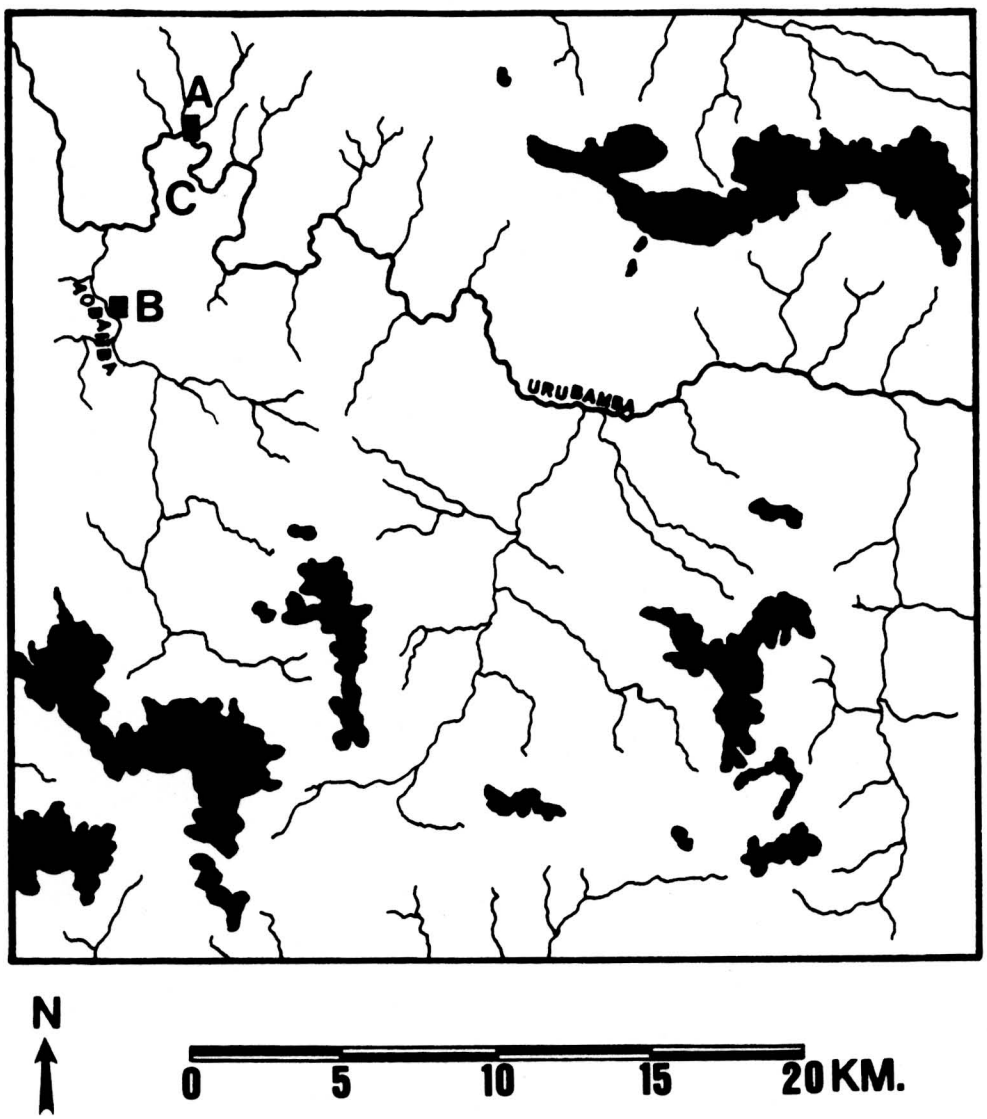

Fig. 1: Study Region: A - Maranpampa training site, B - Aobamba test site, C - Machu Picchu Ruins.

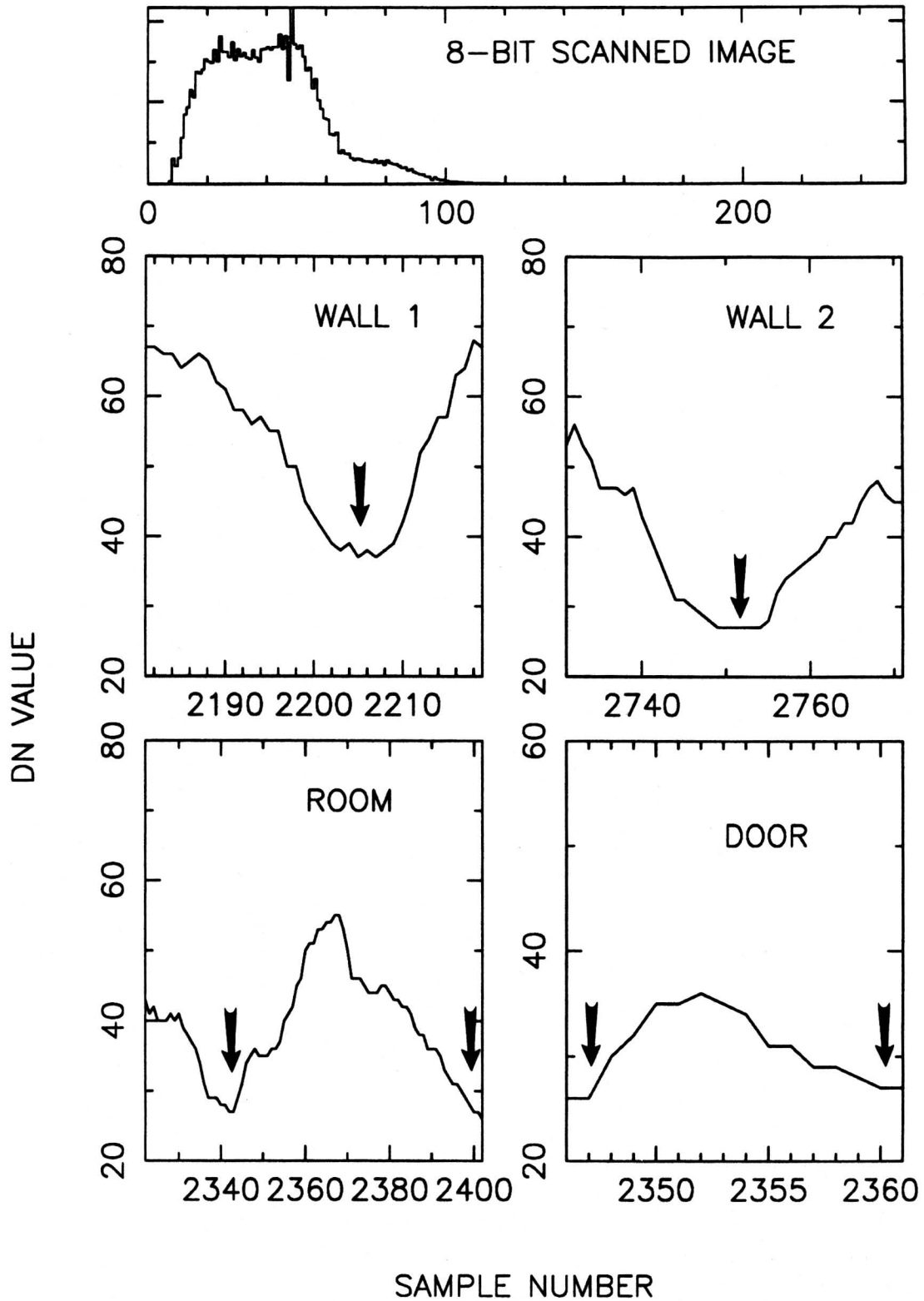

Fig. 2: Histograms of raw data of 8-bit scanned aerial photograph and image profiles of selected structures.

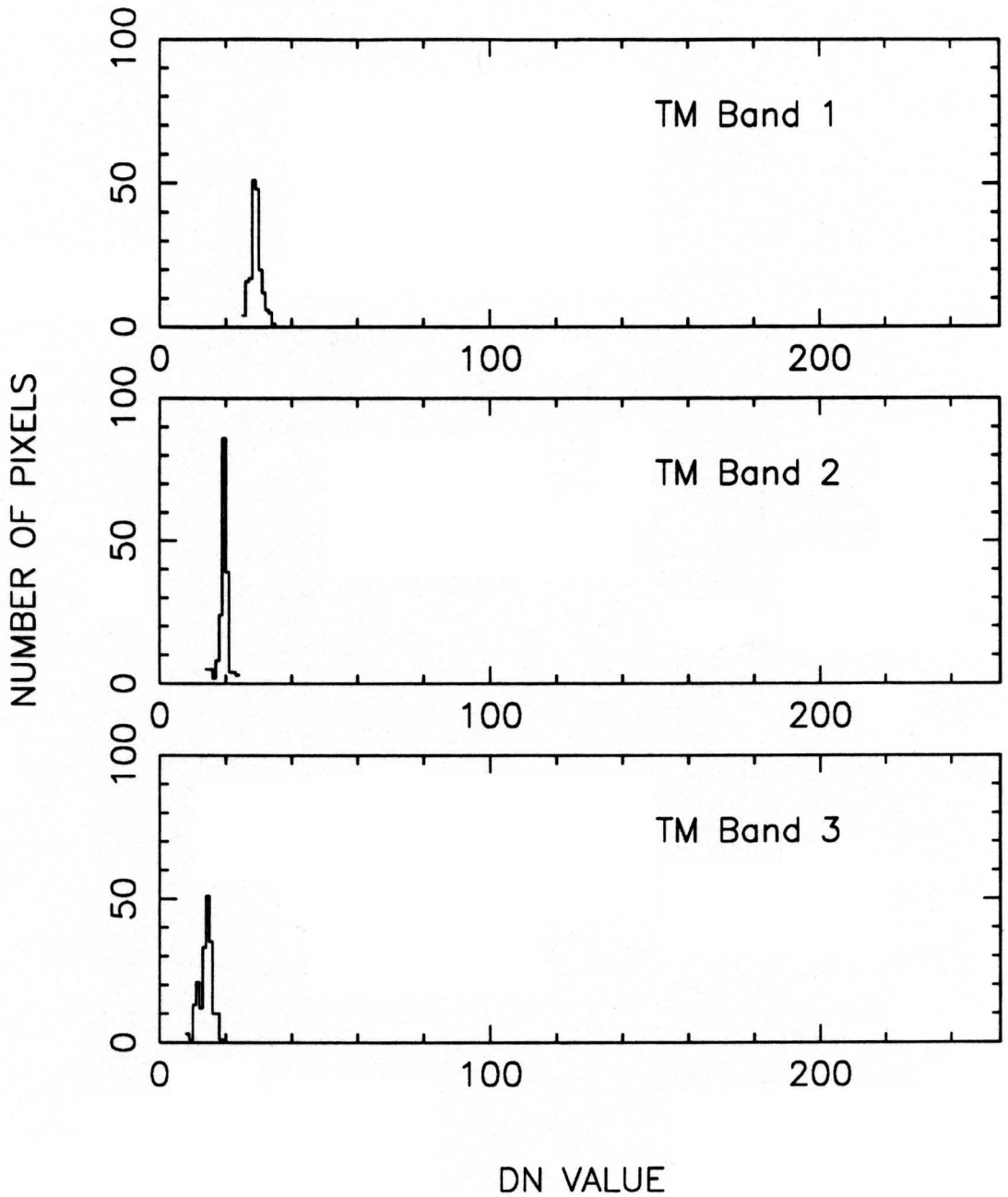

Fig. 3: TM/Landsat raw data histograms of Maranpampa training site.

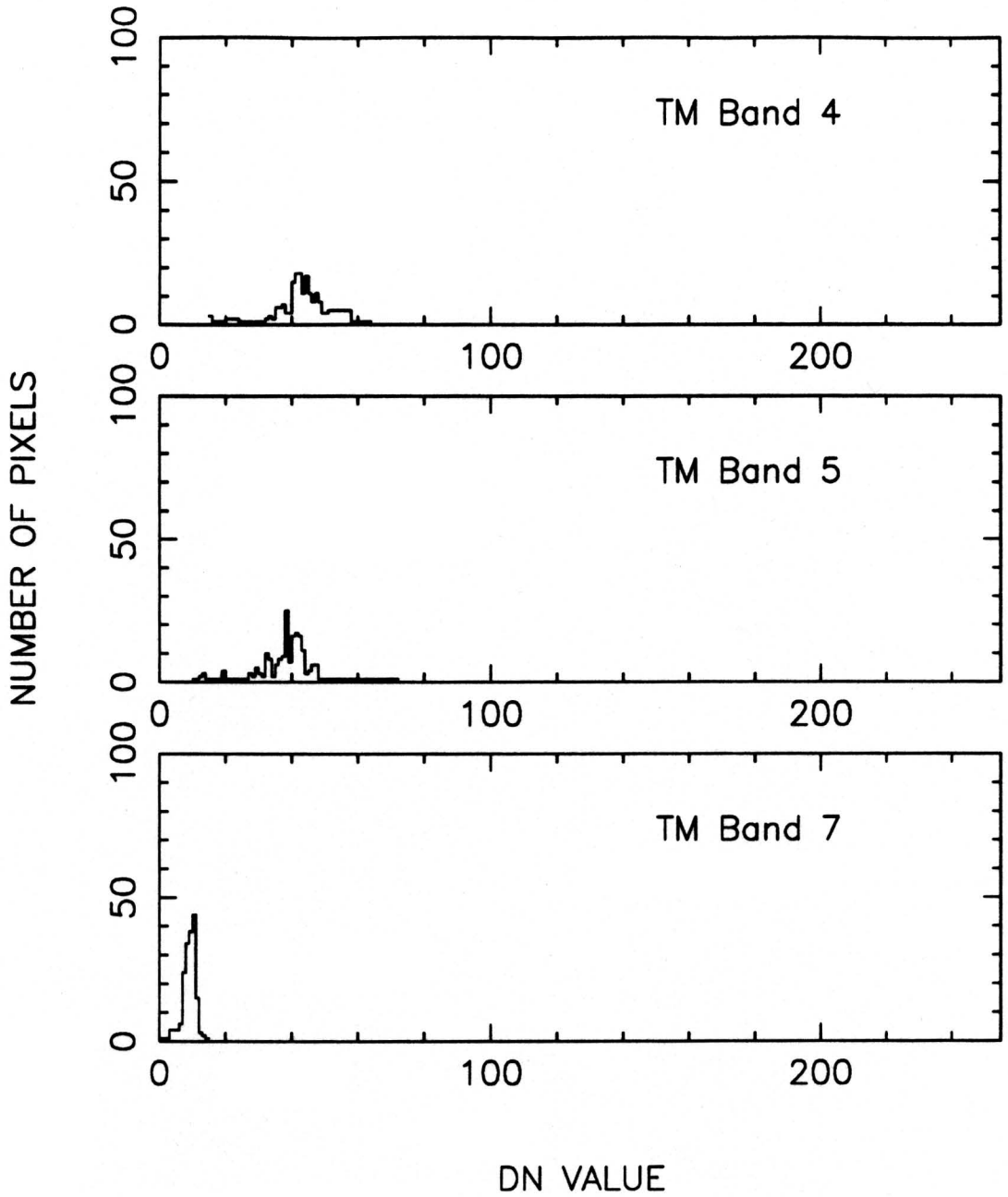

Fig. 4: Tm/Landsat raw data histograms of Maranpampa training site.

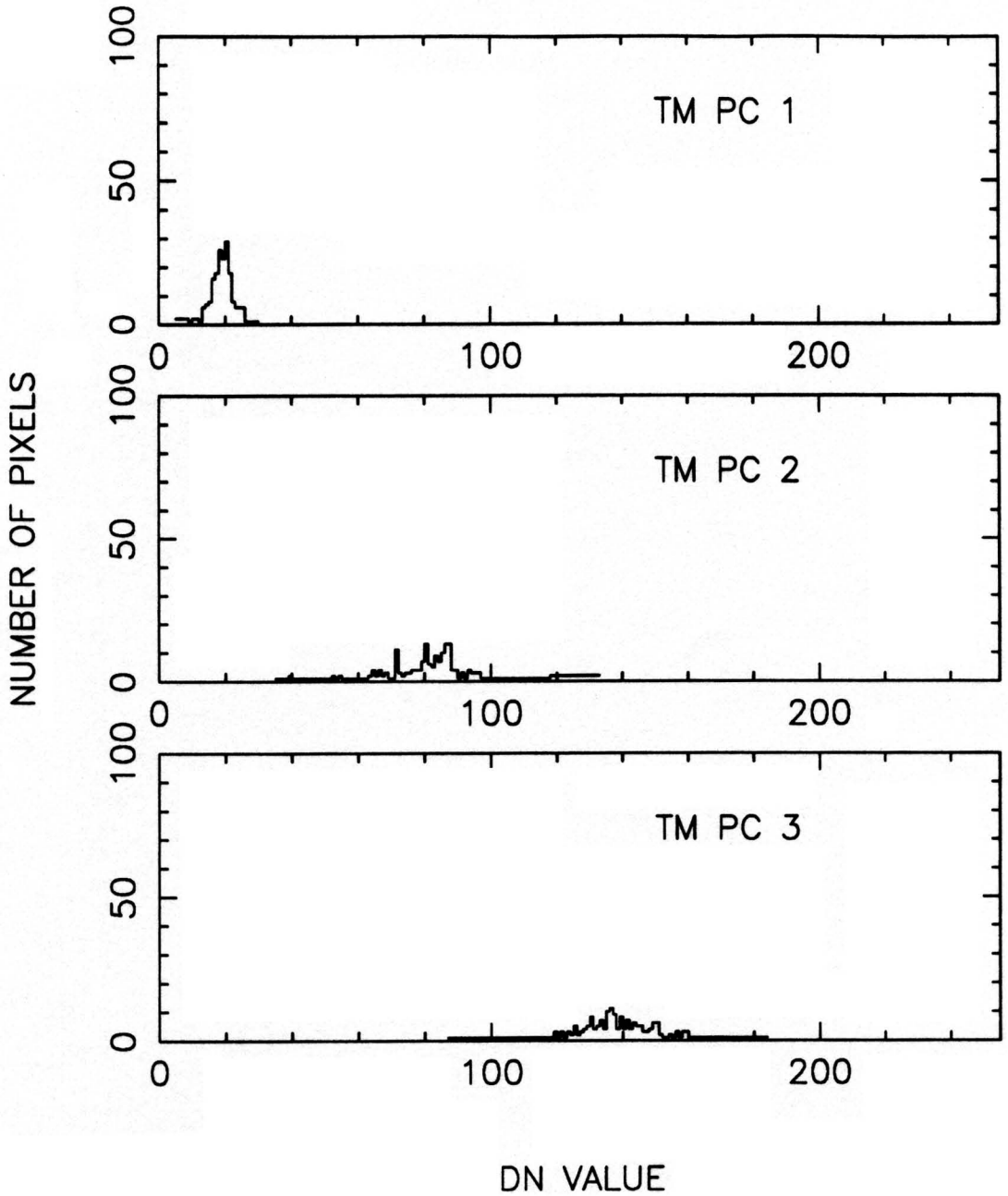

Fig. 5: Tm/Landsat principal component raw data histograms of Maranpampa training site.

TABLE 1

Maranpampa Site - Statistical Data

Image	Total Pixel	Aver. Gray	Std. Dev.	Min., Max.
8-Bit	16.78×10^6	40.02	18.23	6, 136
TM 1	180	28.66	1.72	25, 34
TM 2	180	18.89	1.52	14, 23
TM 3	180	13.44	1.83	8, 18
TM 4	180	41.76	6.97	15, 61
TM 5	180	36.67	7.73	10, 62
TM 7	180	8.59	2.02	0, 14
PC 1	180	17.87	3.72	5, 29
PC 2	180	77.35	14.41	35, 118
PC 3	180	135.42	13.57	87, 174