"THE POTENTIAL OF SATELLITE REMOTE SENSING FOR AMAZONIAN ARCHAEOLOGY: A TEST IN THE MIDDLE UAUPÉS BASIN"

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Current available knowledge about pre-Columbian Amazonian populations is skewed. Most of the archaeological research performed in Brazilian Amazonia has focused on the Amazon itself and its major tributaries (MEGGERS & EVANS 1983), as well as on monumental sites that are more easily recognized at the surface and were already known in the nineteenth century (ROOSEVELT 1991). Most of the hinterlands and the minor tributaries of the basin remain archaeologically unknown. This bias is partially due to the logistical and technical difficulties of doing archaeological research in the tropical forest, but it is also related to the lack of adequate surveying methods for the ecological and cultural characteristics of Amazonia.

In my doctoral research, I intend to evaluate the potential of satelite remote sensing for the surveying of archaeological sites in Amazonia. The use of satelite remote sensing in archaeology is still relativelly limited but its applications are promissing. It allows for the surveying of large areas with comprehensiveness, accuracy and speed (COOPER et all 1991); it allows for the incorporation of ecological, geological, geographical and ethnological variables in the design and development of research projects (MILLER et al 1991); it is particularly useful in detecting land use patterns in remote areas lacking logistical infra-structure (BEHRENS 1991).

The theoretical basis for the research springs from recent anthropological studies on management of natural resources by native Amazonians (BALÉE 1989, MORAN 1990, POSEY 1986, among

others). According to such studies, native populations exert an ingenious action over the environment, managing, shaping, and even modifying it. Such modifications result from both intentional and unintentional actions and they have a long term impact over the landscape, including changes in soil color and texture, and changes in the frequency and density of plant species. The repeated burning of the forest for the opening of gardens; the transplant of plant species from the forest to the vicinity of settlements; the creation of ridged fields and irrigation channels; or merely the long-term occupation of the same spot are some of the ways through which the landscape was transformed by native Amazonians. As a result of this, physical features that were formerlly considered as "natural" are now viewed as products of years of human management (BALÉE 1989).

Among such landscape features, of special interest for my research are so-called "anthropogenic forests" and "anthropogenic soils". Anthropogenic soils, also known "terra preta" soils, are widespread all over Amazonia and are considered a result of human management, since they are commonly associated with archaeological remains (SMITH 1980; EDEN et al 1984). "Terra preta" soils result from carbon-rich hearths fired in relatively low temperatures over decades or even centuries of occupation of the same settlement (SMITH 1980: 557), a common pattern in pre-Columbian Amazonia. The term "anthropogenic forests" refers to vegetation communities that result from human management. More than 11% of upland Amazonian forests - including palm forests, bamboo for-

ests, Brazil nut forests, liana forests, and low caatinga - can be considered anthropogenic (BALÉE 1989: 15). Such forests result either from the conscious management of natural resources, like the transplant of useful species from the forest to the vicinities of the settlements, or from the continuous use of fire over long periods of time. Anthropogenic forests are characterized by the high incidence of certain plant species, in contrast with the pattern of the tropical rainforest, where there is a high density of individuals, but low incidence of individual species.

The distinctive vegetation patterns of anthropogenic forests, combined with the differences in color, texture and pH of anthrosols indicate the former presence of settlements in a particular location. The potential of such type of evidence has never before been evaluated in systematic archaeological studies in Amazonia. The study of satellite remote sensing imagery from the Middle Uaupés basin proposed here would represent an initial effort in this direction.

The Middle Uaupés is an excellent region for the testing of these assumptions due to ecological, historical and ethnographical factors. There is a wealth of information regarding settlement patterns in this area over a period that spans more than two hundred years. There is also in this area a tendency for the continuous occupation of the same spots in the landscape, an ideal condition for the formation of "terra preta" soils and anthropogenic forests.

The Uaupés is a major tributary of the Negro river, and it

is located in Northwest Amazonia. It is classified as a blackwater river, in a threefold typology that also includes clearwater and witewater rivers. Differences in the color of water are related to specific conditions of the catchment areas: nearly pure quartz sandy soils, known as spodsols or tropical soils, are the main source of blackwater in Amazonia. Blackwater ecosystems are known as oligotrophic because of their low nutrient levels. They are composed by a variety microecossistems whose exploitation demand a strategy of diversification (MORAN 1991). Local riparian populations rely on fishing, hunting, gardening and collecting for their subsistence. Fishing and manioc cultivation provide the bulk of the diet: the former for up to 2/3 of the protein intake, the latter accounts for nearly 70% of the carbohydrates (DUFOUR 1983, CLARK & UHL 1987). Spodsols and periodically flooded areas are not suitable for agriculture, reducing the potential cultivating spots to as little as 20% of the land area in the region (CLARK & UHL 1987: 11). Manioc productivity is due more to labor input than to soil quality. Land fertility, therefore, is not an important criterion employed by local populations in ranking one particular location over another with regards to productivity (CHERNELA 1983: 88).

Local populations developed adequate ways to maximize fishing catches, based on the knowledge of the behavior of the fish populations. There are two rainy seasons and two dry seasons in the Uaupés. During the rainy seasons, fishes migrate to the flooded low forest areas in order to feed on the fruits, flowers

and seeds that fall in the water. Other semi-sedentary species live along the river rapids, because of the relatively high biomass content and the sheltering opportunities found in these loci. Fishing species living along the rapids can be considered as almost sedentary because they specialize in exploiting these particular niches (CHERNELA 1983: 242). There are then both spatial and temporal oscillations in the availability of fish along the Uaupés. The implication of this fact for human occupation of the area is that certain resources - in this case availability of animal protein - are spatially and temporaly predictable.

The scarcity and discrete location of fishing spots - big cataracts and flooded forests - constitute an important criterion for the selection of a settlement (CHERNELA 1983: 89). The potentially most productive fishing spots are known by local populations, and such spots are preferentially occupied if there is no form of ideological or political constrains. The Tukanonan and Arawakan speaking populations that live along the Uaupés are hierarchically organized in sibs and phratries that occupy ideologically prescribed loci along the streams (JACKSON 1983). High-ranked sibs tend to be located in areas of higher fishing productivity (CHERNELA 1983). Other locations with a comparatively smaller fishing productivity are also settled, but people exploiting such spots cannot rely on a predictable, periodically renewable, and discretely located source of protein. Settlements located close to optimal fishing spots tend to be occupied for

longer periods of time. An examination of the historical records available for the Uaupés indicate that sites adjacent to the major cataracts have been continuously occupied since the mid-eighteenth century (BRÜZZI 1962, COUDREAU 1886, RODRIGUES FERREIRA 1983, WALLACE 1903, WRIGHT 1981). Throughout more than two centuries of continuous occupation - and consequent management of the surrounding areas of the settlements - sensible modifications in the frequency, density and size of the vegetal species of these areas would be performed by the local inhabitants. These are the conditions for the formation of anthropogenic forests and terra preta soils.

Two areas located along the Uaupés will be selected for this experiment, near the cataracts of Ipanoré and Jauareté. They are both known to be occupied since pre-Colonial times because of the presence of engravings over the rocks. Historical documents attest their continuous occupation since the XVIII century. Both areas are currently occupied by the Tariana people. Studies performed at the Upper Rio Negro basin in Venezuela suggest that the theoretically usable land around settlements is about 2,500 sq. km., in a 5 km. wide strip along each bank of the major rivers (CLARK & UHL 1987: 11). The same figure will be initially used for this experiment, each unit having an area of 25 sq. km.

The project will be divided in three parts, two performed in the laboratory, one in the field. Preliminary laboratory work is being carried out at present with digital satellite data (LAND-SAT) to develop a classification of land cover in the Middle

Uaupés. The data being used are Landsat 5 Tematic Maper scenes from June of 1985, with seven spectral bands and a ground resolution of 30 m., purchased from the National Institute for Space Research in Brazil (INPE). The classification of land cover is being done with ERDAS 7.4, a Geographical Information Systems and Image Analysis software. This analysis includes the determination of the best combination of spectral bands for the analytical goals of the project, and the development of a preliminary classification of the vegetation types in the images. Classification of satellite images can be either unsupervised or supervised. In supervised classification the analist selects groups that represent patterns already known by he/she or that can be identified with other sources, such as aerial photos or maps. Unsupervised classification is performed either as a preliminary approach or when there is no available data for the study area. In this case statistical analysis of spectral ratios - basically different types of cluster analysis - are performed by the computer to divide the data into spectral groups. In the current level of the research there are a number of ethnographic, historical and ecological information available for the region but they still need to be supplemented with data obtained in the field. As a consequence, both supervised and unsupervised classifications are being performed, in order to attain the preliminary mapping of the vegetation features of the region.

The field component of the experiment, starting in January 1993, will have logistical and personnel support of the Museu of

Archaeology and Ethnology, University of São Paulo. It will include an exhaustive archaeological survey of the two study units and a ground verification of the data obtained in the preliminary laboratory work. In the archaeological survey, both informal and formal methods will be employed. Oral information and opportunistic verification of clearings, gardens and open areas will be combined with the use of transects and other formal surveying devices in order to assure a systematic coverage of both areas. Soil samples, material culture, settlement pattern data, and faunal and botanical remains will be collected. No extended excavations are planned, but trenches will be opened in order to understand the chronological and microspatial distribution of the remains and associated features. The goals of the archaeological fieldwork are the following: to assess the antiquity of human occupation in the area; to verify the existence of terra preta soils associated with the remains; to understand the distribution of archaeological sites in the landscape; to obtain data about former patterns of subsistence. As a result, a map of each unit presenting the spatial distribution of archaeological sites will be prepared.

Fieldwork will also include the ground truth of the classification of land cover previouly prepared in the laboratory. In this task I will be assisted by a botanist of the Brasilian National Agency for Agricultural Research (EMBRAPA). A survey of the different plant microcommunites in each study unit will be performed and this information will be further compared with the

land cover maps. The exact location of the vegetal microcommunities on the ground will be provided by a GPS (Global Posistioning System) receiver, which furnishes accurate location, in latitudes and longitudes, within 5 m. The GPS receiver will be provided by Dr. Emilio Moran, of Indiana University, who obtained such equipment from a NSF grant.

Subsequent laboratory work will include the analysis of the archaeological remains. The map with the location of the archaeological sites of the study units will be compared to the data of the vegetation survey and to the classification of land cover prepared in the initial phase of the project. The correlation between archaeological sites and vegetation patterns will be evaluated. This information will be employed for the elaboration of a map containing a supervised classification of land cover and the distribution of archaeological sites in each study unit. The results of this analysis will provide evidence contributing to support or refute the hypotheses about the existence of anthropogenic forests in Amazonia. The archaeolgical research will allow for an initial understanding of the cultural history of the populations of the Middle Uaupés. Finally, this work will contribute to the development of methodologies based in the use of satellite remote sensing for the surveying and study of archaeological sites in Amazonia, expanding the available knowledge about the pre-Columbian history of the region.

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