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Human Ecology from Space: Ecological Anthropology Engages the Study of Global Environmental Change

Emilio F. Moran and Eduardo S. Brondizio

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Anthropological Center for Training and Research on Global Environmental Change
Indiana University, Student Building 331, 701 E. Kirkwood Ave., 47405-7100, U.S.A.
Phone: (812) 855-6181, Fax: (812) 855-3000, Email: act@indiana.edu, internet: www.indiana.edu/~act

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Understanding Levels of Analysis

Contemporary concern in the research community and policy circles with the "human dimensions of global environmental change" offers a rare opportunity to anthropologists. For the first time, policymakers and the physical sciences community have acknowledged the central place of humans in environmental modification (Peck 1990) and thus have implicitly accepted what anthropology might have to say about it. This is a battle that Roy Rappaport fought throughout his career and to which he contributed a great deal. He participated in panels regulating nuclear waste disposal, energy usage, and poverty in America. During his presidency of the American Anthropological Association, he spearheaded two public policy panels of anthropologists to seek ways for the discipline to engage the "disorders" of the modern world—in America (Forman 1994) and in Third World societies (Moran 1996). To date, however, it is an opportunity that seems to have been squandered by the discipline. Anthropologists bring a rich experience to these debates (Johnson and Earle 1987) and familiarity with many of the world's populations that have in the past and into the present managed to develop intensive systems of production, in some cases without the environmental destruction that seems to characterize much of contemporary development. This is the very reason Rappaport gave the authors for the popularity over the years of his first book, *Pigs for the Ancestors* (1968). The answers to our environmental dilemmas today are in large part to be

found in the rich diversity of human experiences in interacting with the environment in the past and present.

For participation in the contemporary debates over the human impact on global environments, ecosystem models and ecosystem theory are fundamental (Moran 1990). An ecological anthropology for the twenty-first century must build on the comparative approaches first proposed by Steward (1955) and complement them with more refined approaches, which permit analysis of global environmental changes and their underlying local and regional dynamics.

One of the tools that will need to be used with growing frequency by ecological anthropologists is geographic information systems (GIS) and the techniques of satellite remote sensing. Remote sensing from satellite platforms such as the National Oceanographic and Atmospheric Administration's (NOAA's) AVHRR (Advanced Very High Resolution Radiometer) sensor, NASA's Landsat Thematic Mapper (TM), and the French SPOT (Système Pour L'Observation de la Terre) satellite provides information of considerable environmental richness for local, regional, and global analysis (Liverman et al. 1998; Conant 1978, 1990).

For analysis of global processes or large continental areas such as the entire Amazon Basin, AVHRR is the most appropriate because of its coarser resolution but daily coverage. Although designed primarily for meteorological monitoring, it has been profitably used to monitor vegetation patterns over very large areas. Because of its scale, anthropologists to date have had little use for these data.

Data from Landsat's Multispectral Scanner (MSS) are valuable for the study of relatively dichotomous phenomena, such as forest cover versus nonforest and grassland versus bare ground, and to establish a long historical account of land cover change. They have been used since 1972 by a number of anthropologists, for example, in the pioneering work of Conant (1978) and Reining (1973). It is one of the most cost effective ways to address many environmental changes of interest, but it still is not very powerful for detailed community-level analysis.

The improved resolution of the Landsat Thematic Tapper (TM) sensor after 1984 allowed more detailed studies of land cover changes in the Amazon Basin, the New Guinea Highlands, and the Ituri Forest of Central Africa (Moran et al. 1994a, 1994b; Wilkie 1994), including discrimination between age classes for subtle palm-based agroforestry management and flooded forest in the Amazon estuary (Brondizio and Siqueira 1997; Brondizio et al. 1994a, 1996), erosion in Madagascar

(Sussman et al. 1994), and intensification in indigenous systems (Guyer and Lambin 1993; Behrens et al. 1994). The Enhanced Thematic Mapper (ETM+) sensor in Landsat 7 is a further improved source of information whose data began to be released in late summer 1999. It permits time-series analysis seamlessly with the earlier Landsat TM and MSS sensors.

These recent advances require that careful attention be paid to issues of both temporal and spatial scale. In earlier work, Moran (1984, 1990) pointed out that many debates on Amazonian cultural ecology were, at least in part, a product of sliding between different levels of analysis without fully recognizing the methodological and theoretical consequences. Appreciation for issues of scaling has increased with the growth of global environmental change studies and their challenge of integrating data and models from different disciplines (Wessman 1992: 175).

In this essay, we highlight the value added of remote sensing to anthropological questions, and vice versa, in ongoing studies on the dynamics of land use in eastern Amazonia. The preciseness of regional analysis depends on the quality of the sampling at the local level. Detailed local-level sampling is far from common in traditional remote sensing. Much of what passes as "ground truthing" is visual observation of classes such as dense forest, or cropland, without detailed examination of land use history, vegetation structure, and composition. The long-standing anthropological bias toward understanding local-level processes, when combined with the use of analytical tools capable of scaling up and down, becomes an important contribution to the advancement of land use/land cover research and to issues of articulation between differently scaled processes. One could argue that in the future refined satellite remote sensing will need the fine ground-level expertise of anthropologists to advance the quality of products from the ever more refined sensors being launched to monitor the earth.

The Use of Remote Sensing in Anthropology

Anthropologists bring to the analysis of global change a commitment to understanding landscape differences and revealing the human behavior behind them. When looking at a satellite image, they search for driving forces behind land use differences, and for land use classifications that are meaningful in socioeconomic and cultural terms. Satellite remote sensing is an area of growing interest among ecological anthropologists studying ethnographic land use patterning and agricultural intensification. Conklin (1980), using aerial photography in his *Ethnographic Atlas of Ifugao,* integrated ethnographic and ecological data to show land use zones from the perspective of the local population. Behrens established a formal basis for using remote sensing and GIS as a means of classifying land use intensification by indigenous Amazonians (Behrens et al. 1994). In Nigeria, Guyer and Lambin (1993) used remote sensing combined with ethnographic research to study agricultural intensification. Their work demonstrates the potential of remote sensing to address site-specific ethnographic issues within a larger land use perspective. A special issue of *Human Ecology* (September 1994) was dedicated to the topic. There was substantial agreement among the articles about the importance of local-level research to inform land use analysis on the regional scale. This conclusion was reinforced in an issue of *Cultural Survival* (1995) dedicated to showing the fruitful connection between local-level knowledge and remote sensing, GIS and mapping tools—and its contribution to indigenous grassroots movements (e.g., demarcating territories).

Contemporary perspectives on the cross-fertilization of remote sensing and social science research are explored in the recent volume *People and Pixels* (Liverman et al. 1998). Examples from anthropology and demography to health and epidemiology applications illustrate the use of remote sensing data from different sensors and applied to different scales.

The challenge posed by complex spatial patterns and problems of scale has opened a new forum for the discussion of theories and methods. It offers an opportunity to the remote sensing analyst to come to the field, measure vegetation, talk to people about land management, and rethink the algorithms used in image analysis. It offers ecological anthropologists the chance to expand the scope of investigation from one or two villages to entire regions; to verify informants' verbally elicited data about land use; and to enrich analyses of spectral patterns, spatial statistics, and the impact of land use on land cover with social content.

Methods of Data Integration

The method of multilevel analysis of land use/land cover change is built upon a structure of four integrated levels of research: The landscape/regional level; vegetation class level; farm/household level; and soil level (fig. 1). The model relies upon a nested sampling procedure that

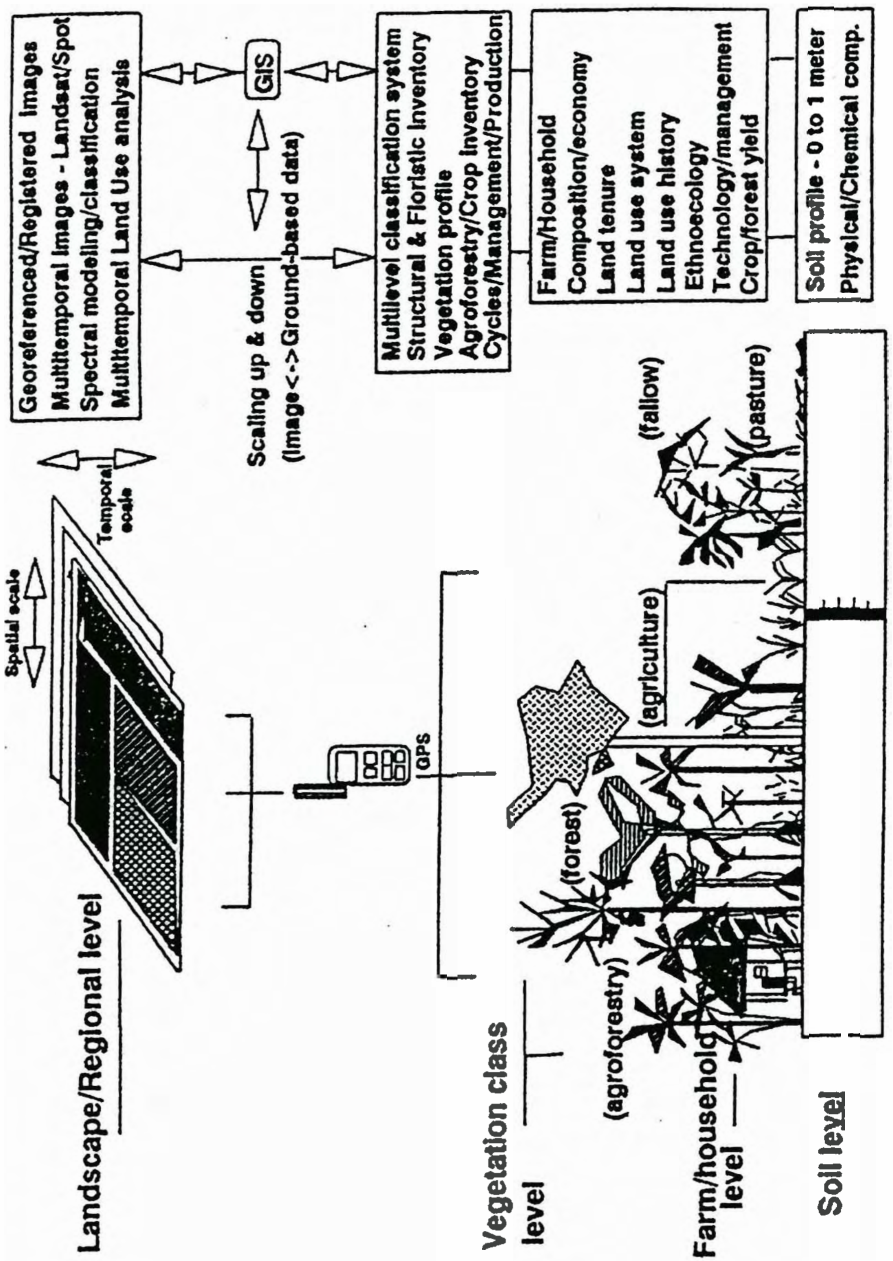

Fig. 1. Methods of multilevel analysis of land use and land cover change. (From Brondizio et al. 1994b and Brondizio 1996.)

produces data that can be scaled upward and downward independently or in an integrated fashion. The integration of multitemporal, high-resolution satellite with local data on economy, management, land use history, and site-specific vegetation/soil inventories aims to make it possible to understand the ecological and social dimensions of land use at the local scale and link them to regional and global scales of land use dynamics. The assessment of land use and land cover change as a function of socioeconomic and ecological factors is a fundamental step toward understanding the sustainability of current forms of land use and the consequences of this action on the region's land cover.

Household/Farm Level

It is important to collect local data so that they can be aggregated with those of larger populations within which households are nested. For instance, demographic data on household composition (including sex and age) can be aggregated at the population level to construct a demographic profile of this population, but this can occur only if the data are collected in such a way that standard intervals of five years are used. Other important data collected at this level are related to subsistence economies and are useful for understanding resource use, economic strategies, market relationships, labor arrangements, and time allocation in productive and "nonproductive" activities. At this level, it is important to cover the basic dimensions of social organization such as settlement patterns, labor distribution, resource use, and kinship (Moran 1995; Netting et al. 1995).

One of the most difficult decisions in land use analysis is about the boundaries of a population. Geographic boundaries are associated with factors such as land tenure, landscape features, and inheritance. An analysis based on local information and maps, images, or aerial photographs can provide more reliable information than either one alone.

Ethnoecological analysis of local resources and management practices may reveal information that most of the time is overlooked by those not delving into "the names that go with things." In the Amazon estuary, local agroforestry management techniques can be discerned but not without familiarizing oneself with local production systems. Data collected at this level can be aggregated to higher levels of analysis in geographical and data base formats. Georeferencing of households, farm boundaries, agriculture, and fallow fields may be achieved through the use of Global Positioning System (GPS) devices. These are small units that permit the precise location of any point on the planet to within a few meters. Data collected at this level also can provide, for instance, information on the distribution of activities throughout the year, the agricultural calendar, and the production season, which can also help determine the best time for future fieldwork.

Vegetation Class Level

Mapping of vegetation cover has implications not only for understanding the impact of land use practices on land cover but also for predicting the sustainability of management practices at the farm level. Basic vegetation parameters need to be included so that they can inform mapping at the landscape level. In general, vegetation structure, including height, ground cover, basal area, density of individuals, diameter at breast height (DBH), and floristic composition are important data points. These data inform the analysis of satellite images and provide clues to the regrowth rate of vegetation following specific types of disturbance and the spatial arrangement of vegetation cover.

From satellite image analysis, the definition of structural parameters to differentiate vegetation types and environmental characteristics such as temperature and humidity are particularly important. Structural differences provide information that can be linked to the image's spectral data. Environmental factors such as soil humidity and color and topographic variations are strongly associated with spectral responses of vegetation cover; hence, their association with vegetation data is important. At the farm level, vegetation structure is the main parameter for evaluating the impact of management practices. At this level, floristic composition assumes a very important role. Some species are excellent indicators of soil type and are associated with given management practices. Farmers commonly use the presence of given species to choose a site for a given farm practice and to predict the pace of regrowth of a site. For instance, the presence of *Imperata brasiliensis* is taken as a sign of low soil pH and slow regrowth in the Amazon estuary.

Information on land use history is important not only to define sampling areas of anthropogenic vegetation (e.g., fallow and managed forest) but also to verify that natural vegetation has not been affected or used in the past. For instance, it is important to know whether a savanna has been burned and, if so, with what frequency. Or, if a particular forest plot has been logged, we must determine which species were

removed and when the event took place. Land use and management history need to be more detailed in areas directly subjected to management (e.g., agroforestry) since management and technology determine the structure and composition of the site. In these areas, estimates and actual measurements of production are critical if we are to analyze the importance of the activity in a broader land use and economic context.

Soil Level

Ethnoecological interviews can elucidate many soil characteristics. Taxonomic classification of soil types based on color, texture, and fertility, in general, can inform the major soil types and distributions with relative reliability. Folk classification can then be cross-checked and compared with systematic soil analyses. Soil analyses should include both chemical and textural examination and permit the aggregation of data to regional levels (Nicholaides and Moran 1995). Soil analyses and ethnopedological studies have a long tradition in anthropology, from the work of Conklin among Hanunóo (1957) to the work of Moran (1975, 1976, 1977, 1981), Moran et al. (forthcoming), and Behrens (1989). In all these cases, the indigenous population proved to have a very refined understanding of soil quality, particularly compared to migrants and developers. Interestingly, soil differences explain more of the variance in rates of fallow regrowth when comparing our five study areas in toto, whereas land use differences explain more of the variance in fallow regrowth when comparing farms within any one of the five study areas (Moran et al., forthcoming). This again suggests the importance of a rigorous level of analysis control and the high probability that explanations will vary with the scale of analysis.

Landscape Level

The landscape/regional level provides the spatial picture of management practices and the driving forces shaping a particular land use and cover. At this level, long-term environmental problems can be better perceived and predicted than at lower scales. This level integrates information from the vegetation class, soil, and farm/household levels. Landscape-level data also inform important characteristics of local-level phenomena that are not measurable at the site-specific scale.

Satellite data are today the most important sources at this level.

However, sources such as radar images, aerial photography, and thematic and topographic maps are also important. Digital analysis of satellite images involves preprocessing, spectral analysis, classification, and postprocessing. During preprocessing, one needs to define the image subset, georeference it to available maps and a coordinate system, and register it to other images available if multitemporal analysis is desired. Georeference accuracy depends on the quality of the maps, the availability of georeferenced coordinates collected during fieldwork, and the statistical procedure used during georeferencing (Jensen 1996). A georeferenced image has a grid of geographical coordinates. For some applications, atmospheric and radiometric calibrations are required (Hall et al. 1991). When multitemporal analysis is desired, images from different dates need to be registered pixel to pixel. This process creates a composite image that provides a temporal change dimension at the pixel level, thus allowing the analysis of spectral trajectories related to change in land use. For instance, in a two-date image (e.g., two images five years apart) one can see the change during regrowth of secondary vegetation.

It is useful to use a hybrid approach during the image classification process. A hybrid approach allows one to analyze spectral signature patterns present in the image in conjunction with ground information to arrive at a spectral signature pattern that accounts for detailed differentiation of land cover features. For instance, in examining a Landsat TM image one attempts to account for chlorophyll absorption in the visible bands of the spectrum, for mesophyll reflectance in the near-infrared band, and for both plant and soil water absorption in the midinfrared bands (Mausel et al. 1993; Brondizio et al. 1996). The integration of these spectral features with field data on vegetation height, basal area, density, and dominance of species can be used to differentiate stages of secondary regrowth. The analysis of spectral statistics derived from unsupervised clustering and areas of known features and land use history allow the development of representative statistics for supervised classification of land use or land cover.

Classification accuracy analysis requires a close association with fieldwork and may decrease as spatial variability increases. Thus, ground-truth sampling needs to increase in the same proportion. In this case, the use of a GPS device is necessary to provide reliable ground-truth information, whereas in more homogeneous areas visual spot checking may be enough. An accuracy check of the temporal image requires the analysis of vegetation characteristics and interviews about the history of a specific site so that one can relate past events to present aspects of the land cover (Mausel et al. 1993).

Data Integration

Integration of data at these scales is an interactive process during laboratory analysis of images and field data and during fieldwork (Turner and Meyer 1994). Advanced data integration and analysis is achieved using GIS procedures that integrate layers of spatial information with georeferenced data bases of socioeconomic and ecological information. Georeferencing of the data base to maps and images must be a consideration from the very beginning of the research, so that appropriate integration and site-specific identifications are compatible. Data on household/farm and vegetation/soil inventories need to be associated with specific identification numbers that georeference them to images and maps so that integral associations can be derived. For instance, properties' boundaries may compose a land tenure layer that overlaps a land use or land cover map. These two layers may be overlapped with another layer and contain a distribution of households. Each household has a specific identification that relates it to a data base with socioeconomic, demographic, and other information. In another layer, all the sites used for a vegetation and soil inventory can be associated with a data base containing information on floristic composition, structural characteristics, and soil fertility, which will also relate to land use history.

Land Use and Land Cover Classification

Designing a classification system of land cover types and land use classes is a first step toward a good classification of land cover that allows inference about land use. This can be achieved through the association of bibliographies and data bases of the study area, analysis of satellite images, fieldwork observation, and ethnoecological interviews with local inhabitants. Different levels of organization are required to define the land cover of a region. In general, levels are organized to fit a specific scale of analysis into the phytogeographical arrangement and into land cover representing the land use types present in the area. In other words, one starts with a more aggregated level of major dominant classes (first) adequate to a regional scale and proceeds with increased detail at the next sublevel (second) to inform more detailed scales. For instance, the first level may include major vegetation covers such as forest, secondary succession, and savanna. At the second, more detailed level, forest is subdivided into open and closed forest, secondary succession into old secondary and young secondary succession, and savanna into grassland and woodland savanna. At the third level of this classification system, still more detailed information needs to be included to account for the variability of vegetation required at this local scale. So a new subdivision of the forest class may include a third structural variation of the former two and/or a floristic variation of them such as a forest with a dominant tree species. The importance of developing a detailed classification key is crucial to informing the land use and cover analysis at the landscape level as well as the sampling distribution at the site-specific level (fig. 2). We now briefly review three examples of the application of these approaches.

Example 1. Studies of Secondary Succession in Amazonia

Our research on secondary succession in Amazonia has taken into account regional and local differences in soil fertility and land use history. By combining the analysis of Landsat TM images and field inventories of secondary vegetation, our research has tried to achieve an understanding of both the landscape distribution of secondary vegetation and the ecological processes of vegetation regrowth at the stand level. This research has found that soil fertility is a significant indicator of differences in forest regrowth between regions. As can be seen in figure 3, during the first five years of regrowth, Altamira fallow regrowth is a meter higher compared to the average fallow of all other regions studied. This difference increases twofold in fifteen-year fallows.

We have been able to distinguish three structural stages of forest regrowth that characterize the initial (SS1), intermediate (SS2), and advanced (SS3) phases of forest regeneration (e.g., Mausel et al. 1993; Moran et al. 1994b; Brondizio et al. 1994a). Mapping the amount of each of these classes of forest regrowth helps to characterize the landscape and land use strategies. Figure 4 shows the distributions of land cover classes in four of our study sites (Altamira, Marajó, Igarapé-Açu and Yapú). At a glance, one can see the effects of long-term settlement in the Igarapé-Açu region, where mature forest has virtually disappeared and the landscape is dominated by secondary vegetation in different stages of development. In contrast, the Yapú area, with a low population density and a long fallow swidden form of land use, shows little impact on the forest cover (DeCastro et al., forthcoming). The more

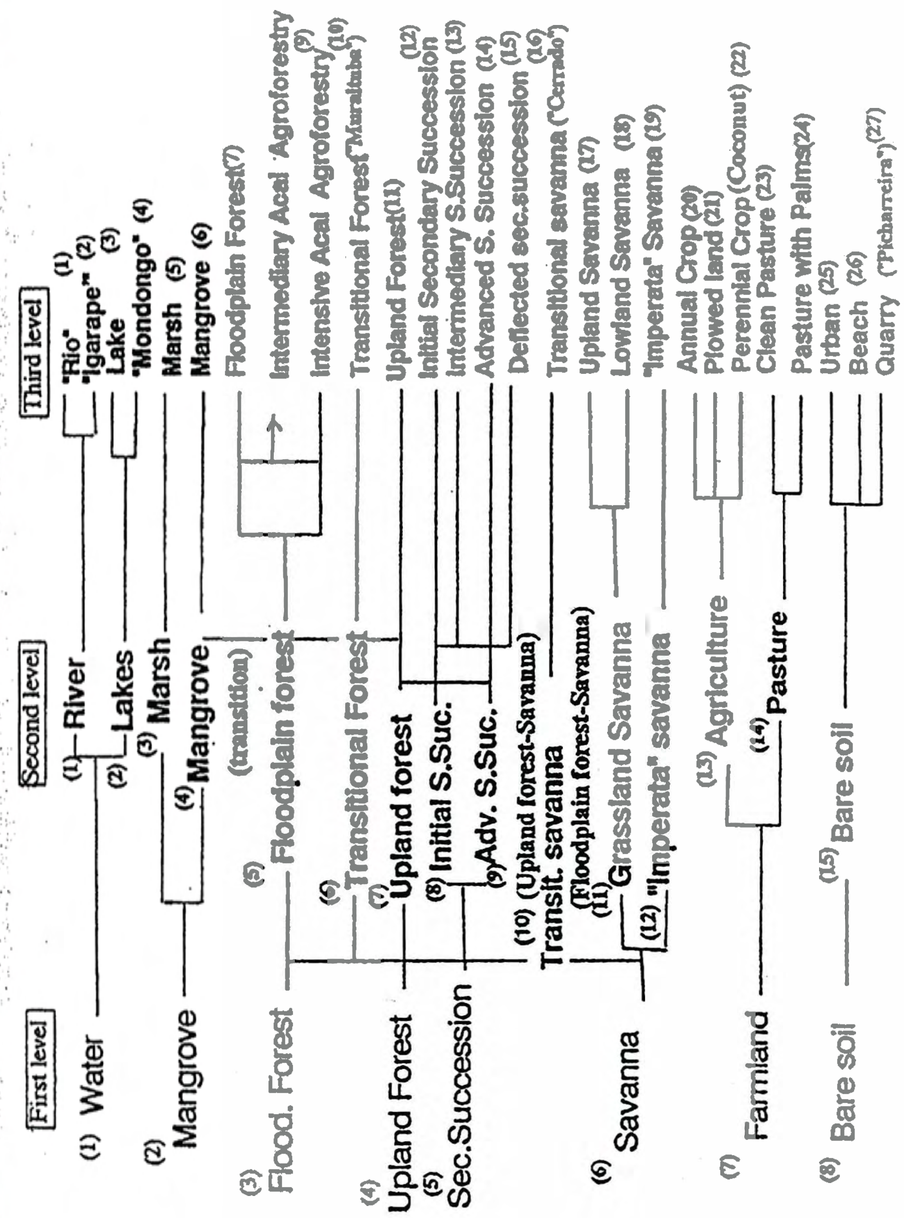

Fig. 2. A multilevel land use and land cover classification system including local discrimination of vegetation types. (From Brondizio 1996.)

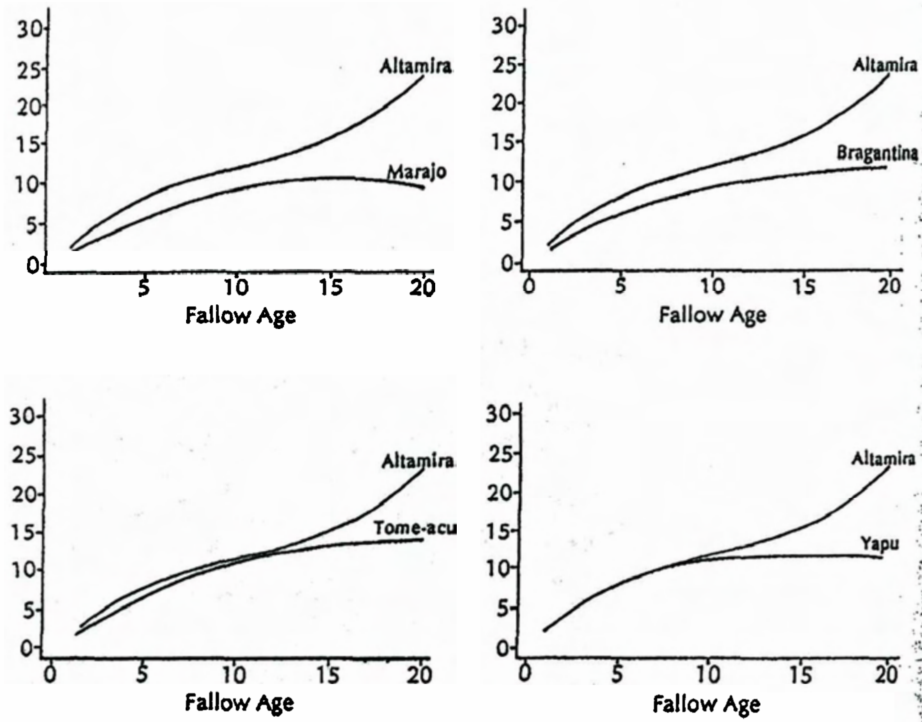

Fig. 3. Height increment in secondary succession. (From Moran and Brondizio 1998.)

recently colonized Altamira area, although largely forested, shows signs of sizable areas occupied by secondary vegetation due to overclearing by inexperienced settlers and the stimulus of bank credit.

Understanding the patterns of forest regrowth in these areas provides clues that could help us to improve the management of shifting cultivation cycles, to increase the economic use of fallow areas (e.g., with medicinal, ornamental, and fruit species), and to develop techniques of enrichment with hardwood species that could lead to less pressure on areas of mature forest to produce economic gain.

Example 2. Population-Level Land Use Patterns in the Amazon Estuary

This example shows the application of Landsat images to distinguish between settlement and land use patterns of Caboclo populations in the

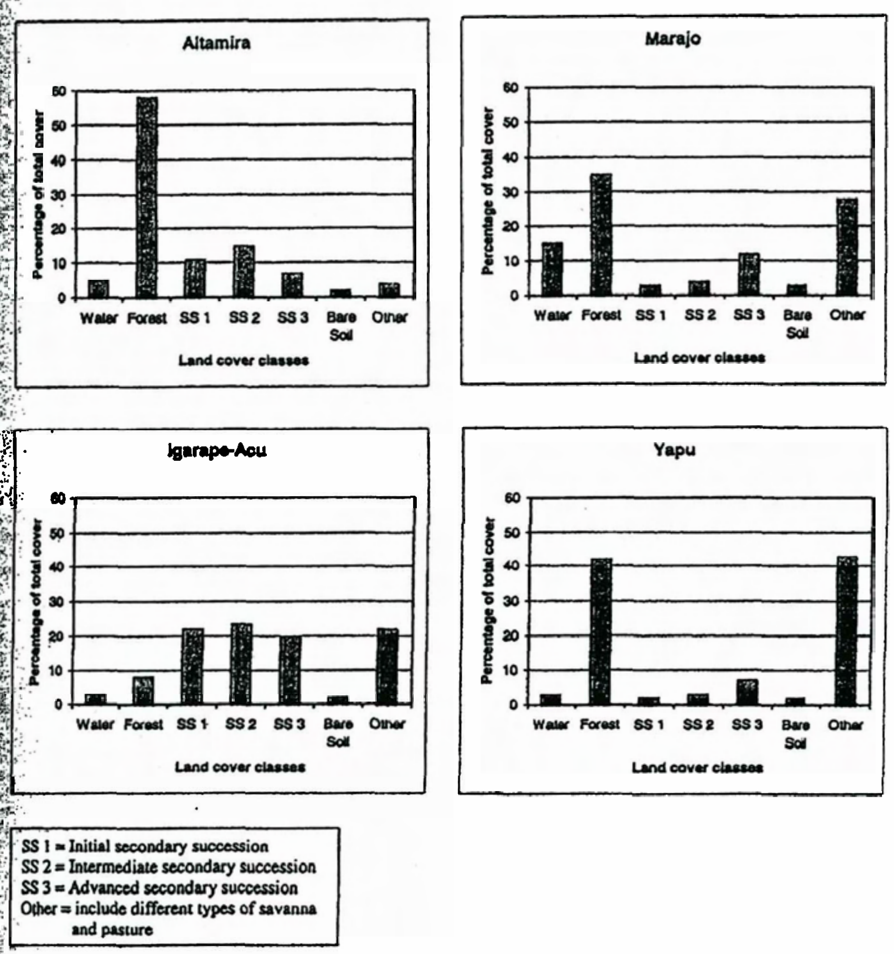

Fig. 4. Contrast in land cover classes at four study areas

Amazon estuary (fig. 5). The region is located around the town of Ponta de Pedras on Marajó Island. It is a transitional area characterized by a rich array of vegetation types such as floodplain and upland forests, mangrove, different types of savanna, and secondary vegetation. Land use types include swidden and mechanized agriculture, floodplain agroforestry, extractivism, and cattle ranching. The complex matrix of land use and land cover types occurring over short distances has provided us with an opportunity to test and develop new approaches to integrating

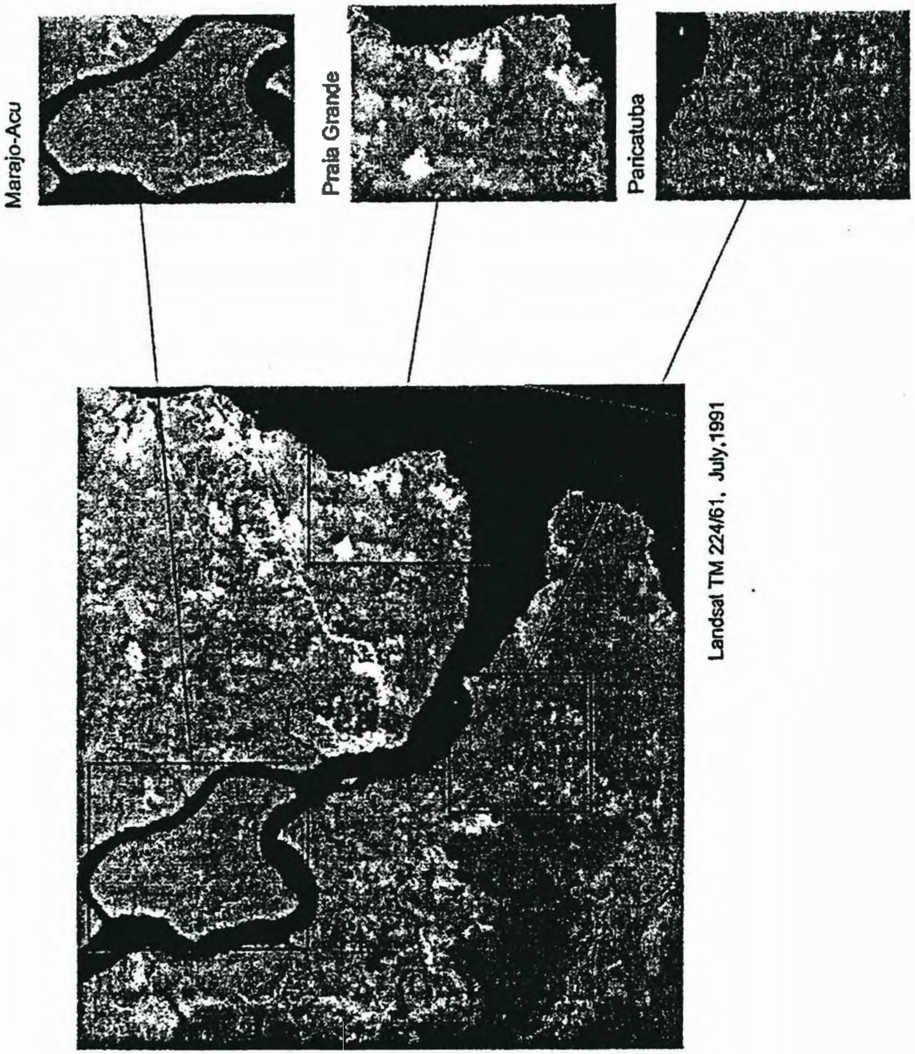

Fig. 5. Satellite images of Ponta de Pedras, Marajó Island, PA, Brazil.

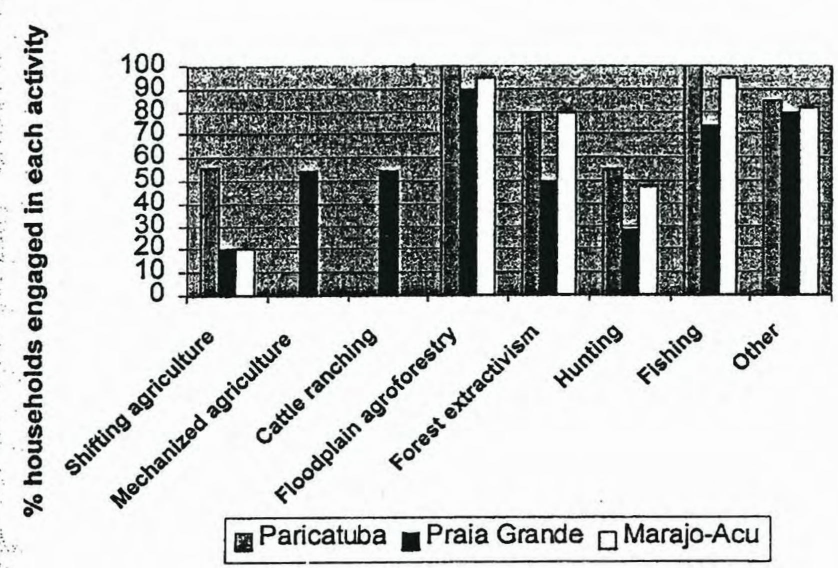

Fig. 6. Differences in activities in three communities of the Amazon estuary. (From Brondizio et al. 1994a.)

remote sensing data with local-level information on land use strategies carried out by local populations.

In this example we used remote sensing and socioeconomic data (collected through household interviews) in analyses of land use and cover patterns. Whereas figure 5 is a TM composite image illustrating the spatial configuration of land-use and cover for three estuarine populations, figure 6 describes the percentage of households in each population engaged in differently patterned economic activities. The use of TM data to discriminate land use and cover classes at the scale of small populations poses a number of challenges to image classification. It requires linking the spatial resolution of TM images with the spatial resolution of small-scale land use practices such as swidden agriculture and açaí agroforestry (Brondizio et al. 1994b; Brondizio and Siqueira 1997). Açaí (*Euterpe oleracea mart*) is the vernacular name given to a multistem palm that occurs naturally in floodplain areas of Eastern Amazon. The abundance of açaí palm in floodplain forest, together with its multistem regeneration capacity, makes it a species highly suitable for management. Açaí fruit, after being processed into a thick juice, is a highly appreciated regional staple food in rural and urban areas alike. In rural and peri-urban areas, açaí juice is the second most important caloric source, behind manioc flour, and during the past twenty years it has become one of the most important economic resources for a large number of municipalities in the Amazon estuary.

A notable association between the continuity of forest cover and the types of land use strategies carried out by each population can be observed. Two examples can be highlighted. In the Praia Grande subregion, the landscape is characterized by a mosaic of open areas and secondary vegetation. This reflects the fact that over 50 percent of the households are involved in cattle ranching and mechanized agriculture. The presence of a continuous floodplain forest (cutting diagonally from the southwestern part of the image to its center) illustrates the impact of different land uses on land cover. Despite large-scale deforestation in the area, floodplain forest has been maintained as a result of the engagement of this population in *açaí* agroforestry. In contrast, in examining the Paricatuba subregion one can see the importance of swidden agriculture in the areas of upland forest surrounding the floodplain forest adjacent to the local river. A mosaic of small opened areas and secondary successional vegetation surrounding the river headwaters in a circular fashion can be seen. Finally, by looking at the Marajó-Açu subregion and the socioeconomic data, one can begin to understand the shifts this population has experienced during the past twenty years. Newly opened areas are virtually absent (the dark gray areas surrounding the forest are natural grassland) since most of it is now under some stage of secondary succession. This is due to the virtual abandonment of swidden agriculture in favor of *açaí* agroforestry.

Example 3. Household-Level Land Use Change in the Transamazon Highway

This project examines differential land use as it relates to household age and gender composition, growth, and change using a combination of household-level field surveys to scale up to the regional level using GIS techniques. The project hypothesizes that while many other factors noted in the literature, such as credit policy and migration flows, are important, the overall pattern of deforestation is shaped to a much greater extent by the household composition of labor over the course of the domestic life cycle. In this project, we are surveying over four hundred households from a total of more than three thousand properties (McCracken et al. 1999). Figure 7 illustrates the process of GIS development and the use of

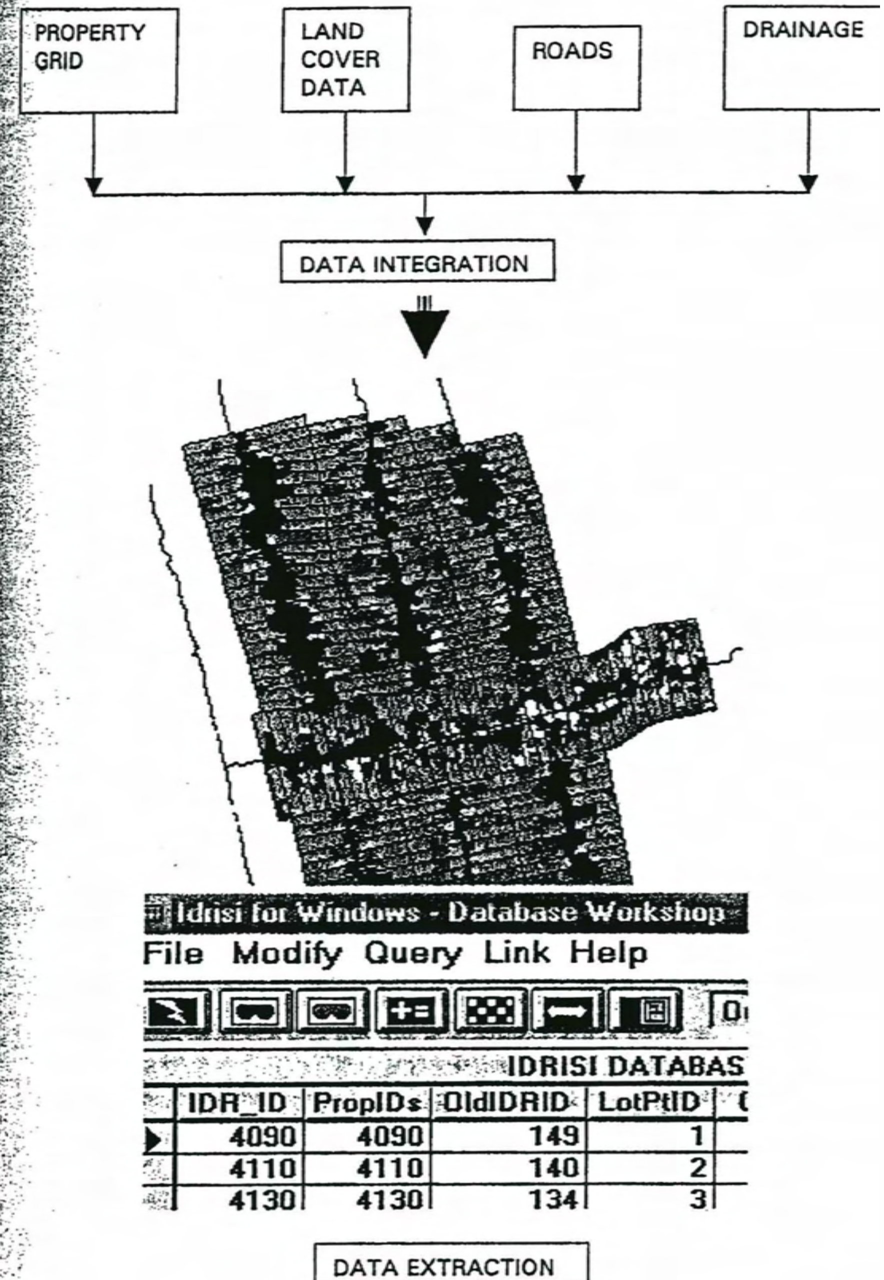

Fig. 7. Data integration and extraction in a GIS

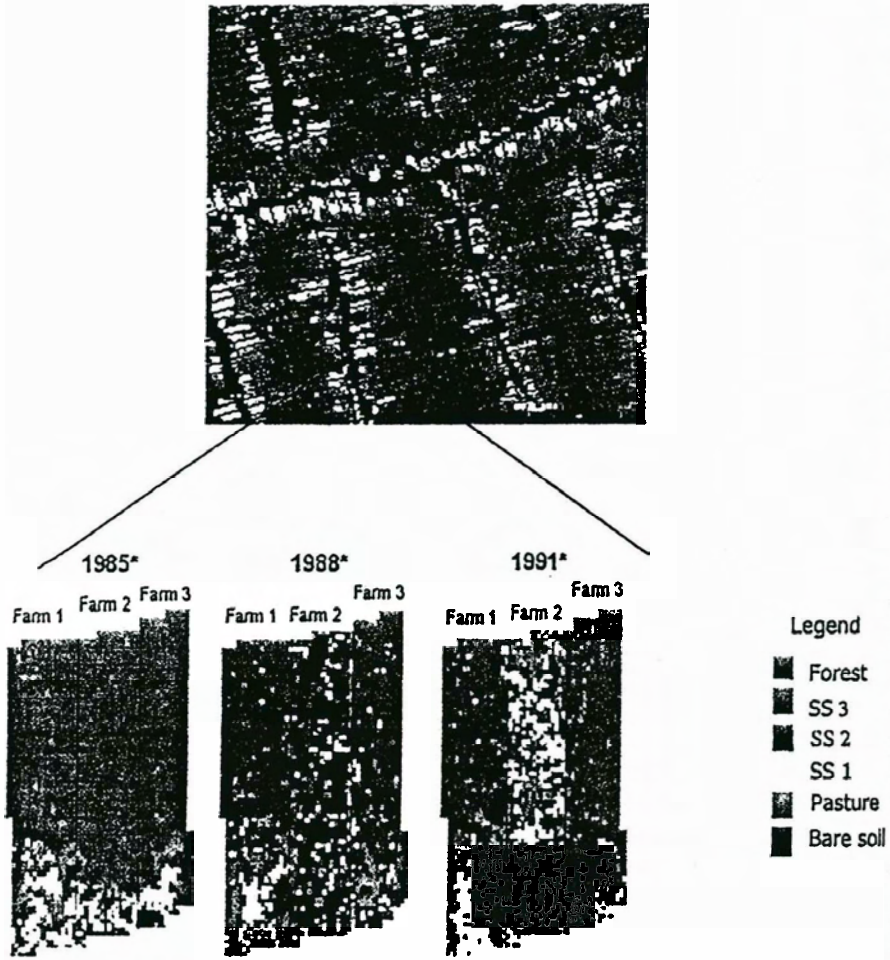

Fig. 8. Contrasting land cover in three farm properties over time. (Classification derived from Landsat TM images, 1985, 1988, 1991.)

a property grid (farm definition) to extract multitemporal land cover data (Brondizio et al., forthcoming).

The examples shown in figure 8 help to illustrate the differences in farm-level land use investigated by the project. By comparing the three neighboring farms presented in the sample, one can see considerable variations in land use strategies. Farm 1 which started with higher deforestation, put in annual crops and pasture between 1985 and 1988 but largely abandoned most of them by 1991. In contrast, farm 2, which presented little deforestation in 1985, by 1988 had completely deforested the property and switched to annual crops. This farm shifted from annual crops in 1988 to large areas of pasture by 1991, including degraded pasture. Dissimilarly, farm 3 maintained a small deforested area between 1985 and 1991, which was also initially dedicated to crops followed by pasture. In all three cases, it is important to note that areas in intermediate secondary succession may represent agroforestry areas of cacao due to the similarity in height and basal area between SS2 and cacao agroforestry.

Conclusions

Rappaport personally, and through his writings, inspired the authors' interests in issues of scales of analysis. His comment in the final pages of *Pigs for the Ancestors* to the effect that local populations are highly ephemeral and anthropologists would do well to begin to study local populations as they exist within a regional system led us over time to explore how landscape ecology, and other regional approaches might enrich anthropological and environmental studies. With the development of global change studies, this has added another wrinkle to this type of work: engagement with disorders of the contemporary world such as global deforestation, poverty, devaluation of local environmental knowledge, and finding local solutions to environmental problems rather than imposing outside solutions. Anthropology is capable of contributing to these analyses, with its forte remaining at the local to regional scales. Wessman (1992: 180) has called for studies that link ground observations to regional and global scales if we are to take full advantage of the detailed data available at different scales. A number of these research efforts are currently under way, but they have paid scant attention to the human dimensions of these processes. Extrapolation of ecosystem research to the regional and global scales has been hindered in the past by difficulties in observing large-scale spatial heterogeneity and long-term patterns of successional dynamics.

Remote sensing linked to ground-based studies provides the most promising of tools for understanding ecosystem structure, function, and change, with an explicit link to human activities (Liverman et al. 1998). The capacity to detect long-term change in ecosystems can be enhanced by analysis of image texture combined with spatial statistics that permit analysis of stand structure from satellite data (Wessman 1992: 189), just as ethnoecology gives us access to the ways in which people perceive resources and their uses. In this essay, we have provided a summary of a multilevel research strategy that links traditional anthropological field methods to regional scale approaches based on satellite digital data from high-resolution sensors. It is one step toward a growing capability to complement our traditional methods of field study with space age techniques to capture landscape heterogeneity and a truly regional approach to human ecology. This strategy is not a purely programmatic statement but, rather, a well-tested research strategy used by a multidisciplinary team at the Anthropological Center for Training and Research on Global Environmental Change since 1992 and more recently by the Center for the Study of Institutions, Population, and Environmental Change (CIPEC), both at Indiana University. Results of this work may be found in the references cited throughout the paper or, as of May 2000, at the team's home page: www.indiana.edu/~act/.

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