The digital land systems surveys for monitoring land quality change in the Amazon

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Summary and Objectives

In recent years the compilation of digital databases has resulted in significant advances in understanding the nature of the land resources of the Amazon and its adjacent savanna lands. The first computerized study that covered this region was co-sponsored by the International Center for Tropical Agriculture (CIAT) and the Brazilian Savanna Agricultural and Animal Research Center (EMBRAPA-CPAC), (Cochrane et al., 1985). It was a low profile, low-cost study that illustrated the feasibility and benefits of compiling digital databases of the land resources of extensive tracts of land.

The computerized land systems approach was subsequently adopted by the World Soils and Terrain Digital Database Project (acronym SOTER, an abbreviation of soil and terrain), which started as an International Soil Science Society (ISSS) initiative in the mid 1980s (van Engelen and Wen eds., 1995). The initial objective of the SOTER project was to develop a digital database file system of terrain and soil properties to be described according to internationally accepted definitions (Shields and Coote eds., 1988). In this way, land quality could be compared using the same parameters from region to region, and changes monitored over time.

The objective of this article is to draw attention to the several and extensive computerized land resource geographic information systems (LR-GIS) studies that have been carried out in Amazonia and the savannas of central Brazil using the SOTER file system, as these may be used as a basis for monitoring land change.

Materials and Methods

The approach is a refinement of the land systems concept developed by Christian and Stewart (1953). Underlying the SOTER philosophy was the identification of areas of land "with distinctive, often repetitive patterns of land form, lithology, surface form, slope parent material and soil" (van Engelen and Wen eds., 1995). These landscape units are termed SOTER Units, which in turn can be subdivided according to their varying terrain characteristics into so-called "Terrain Components" and sequentially into "Soil Components". The landscape units are identified in the field and delineated on geo-referenced satellite and radar imagery. The properties or attributes of the SOTER Units and their subdivisions are described by the SOTER database file set that was designed to be independent of scale. However, the physical mapping of their subdivisions are limited by scale considerations. The SOTER database has additional files for Climate, Vegetation and Land-Use, all with attributes described according to internationally agreed-upon parameters.

In designing the architecture of the LR-GIS it was decided to use separate Relational Database Management RDBM programs, offering greater flexibility, for the SOTER attribute file set and link the latter to GIS programs to manage the map files of the geographically delineated SOTER Units and their subdivisions. The system permits the use of virtually any combination of commercially available RDBM software with GIS programs. Examples would be the combination of MS Access with ArcView or PARADOX-dBase with IDRISI. Clearly, by so doing, the attribute and map file sets can readily be used in updated versions of the software. The system also integrated the FAO-ISRIC-CSIC Multilingual Soil (profile) Database SDBm (1995) by linking the latter with the SOTER attribute files. Care was taken to ensure that the system was open to facilitate linkage with other databases.

The resulting LR-GIS file sets were produced as Personal Computer (PC) Users' Packets compatible for use with different combinations of RDBM and GIS software programs. The recent land resource study of the Brazilian Amazonian state of Rondônia provides an example together with a detailed manual of the methodology (Cochrane and Cochrane 1998).

Results and Discussion

Some findings from the main studies, which were carried out in the region as opportunities arose (Figure 1), follow:

Figure 1. Study regions.

The test study of the Geo-economic Region of Brasilia

In coordination with the SOTER program centered at ISRIC in Wageningen, Holland, a test study using the methodology in a preliminary format according to the provisional SOTER manual then available (Shields and Coote eds., 1988), was carried out over the Geo-economic Region of Brasilia (Figure 2). The latter is predominantly a mid-altitude tropical savanna area found on the Pre-Cambrian plateau formation of central Brazil, with the capital of Brazil as its epicenter. It covers a region about the size of the country of Uruguay.

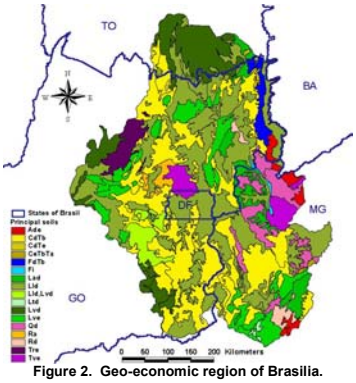

Figure 2. Geo-economic region of Brasilia.

An interesting finding of the survey was that it provided statistical data to show that the basic reason for the existence of savannas on the soils throughout the region was the presence of an imbalance between Ca and Mg in those soils (Cochrane, 1989). This illustrates the usefulness of statistically adequate sampling of soils during the course of the field studies.

The database provides valuable information for the more efficient application of lime and fertilizers to improve crop production throughout the region.

The land resource studies of Bolivia's Amazon

A land resource study of a substantial area of western Amazonia, the Brazil nut region of northern Bolivia, was carried out in 1992 with World Bank financing (Cochrane et al., 1992), at the 1:250,000 scale. This was followed by a territorial Land Use Zoning study of a large part of that region, the Pando Department of Bolivia, which was financed by the Dutch Government (Cochrane et al., 1993). The work was carried out to provide a land resource database for the sustained development of the region. In the case of the Pando study, one of the many thematic maps prepared was a Land Use Zoning map (Figure 3) to identify extractive reserves for non-timber forest products including Brazil nuts, national parks and other uses, to be put into effect by the local government.

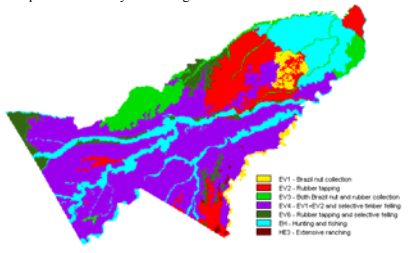

Figure 3. Land zoning in the Pando department of Bolivia.

The land resource study of the Amazonian State of Rondônia, Brazil

The objective of the soils and terrain land resource survey of the Amazonian State of Rondônia, Brazil (Figure 4), was to make an evaluation of its land potential, and so provide a basis for the orderly development of the state through zoning of sustainable agricultural, pastoral, forestry, and conservation activities.

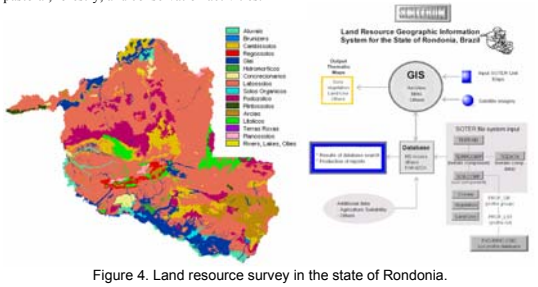

Figure 4. Land resource survey in the state of Rondonia.

The SOTER studies showed that Rondônia has a complicated mosaic of land and soil conditions. Soils vary quite significantly from place to place in terms of both their physical and chemical conditions. (Descriptions and detailed analyses of over 3000 soil profiles were recorded in the database). Unfortunately, the indiscriminant destruction of the native forests seen over much of the region cannot be condoned, as it has resulted in a considerable loss of biodiversity.

The land resource database of Rondônia was recorded as the PC Users' Packet titled "SIGTERON" (The Geographic Information System of the Terrain and Soils of Rondônia) (Cochrane and Cochrane, 1998). The manual accompanying the PC Users' Packet provides a complete compilation of the updated methodology and attribute definitions, which should be of considerable use in carrying out future studies. SIGTERON is a benchmark study that will provide a wealth of information for many years to come.

Conclusions

The philosophy of producing a LR-GIS that incorporates the SOTER file set organized as a PC Users' Packet, is a technological approach that has been well proven over the central savannas of Brazil and the Amazon. The work has provided a wealth of readily available, analyzable information of use to farmers and conservation planning. Should land resource scientists (including soil, vegetation, land usage and land use monitoring specialists), wish to carry out additional computerized studies, they can build on an existing PC Users' Packet. The approach could be used for monitoring land change not only throughout the Amazon but also in other under-developed tropical regions of the world.

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