MAPPING TROPICAL LAND USE FROM MULTI-SENSOR IMAGERY

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ABSTRACT:

Landsat multispectral scanner (MSS) and thematic mapper (TM) satellite images of the remote, rugged BOSAWAS Reserve of northern Nicaragua were employed to map land cover/use for 1986 and 1995, and to assess the changes that have occurred between these dates. Supervised methods permitted five land cover/use categories to be classified from the digital satellite images. The boundaries of these thematic classes were then delineated using on-screen digitizing techniques to create vector coverages. In addition to land cover/use, the hydrography, transportation networks, population centers and boundaries of indigenous claims were digitized from existing maps, and incorporated into a vector format geographic information system (GIS) database. The coverages for the two dates were then placed in register to identify land cover/use changes for the period 1986-1995. Analyses to date reveal that encroachment and deforestation is occurring in the southern and western portions of the Reserve. The database and thematic maps will be provided to the Nicaraguan government to serve as a foundation for the management of the BOSAWAS Reserve.

1. INTRODUCTION

Current maps and land cover/use data in digital format are needed to establish a land resource management plan for the BOSAWAS Reserve in northern Nicaragua. Such a plan is required to insure the preservation of large stands of native tropical forest threatened by exploitation, provide a basis for sustainable economic development and protect the territorial integrity of the indigenous population in the two million hectare Reserve (Bowermaster 1995). Because of the size of the land area and its inaccessibility, satellite images recorded since 1986 are being used to construct the land cover/use maps and an associated digital database compatible with the ESRI ARC/INFO geographic information system (GIS) software package.

The BOSAWAS Reserve was established in 1991, shortly after the conclusion of a civil war that precluded economic development during the 1980's (Nietschmann 1990). It derives its name from the Bocay River, Saslaya Mountain and Waspuk River. The Reserve is the headwaters for the Prinzapolka and Coco Rivers. The latter separates the Reserve from Honduras to the north.

BOSAWAS is occupied by two indigenous groups, the Miskito and Mayagna and more recently by mestizo settlers who, with the coming of peace in 1990, have begun to occupy land along the southern edge of the Reserve and along rivers extending into the interior. As a consequence of its remoteness, native populations and recent influx of settlers, land tenure is in disarray. Consequently, with the establishment of the Reserve, the Nicaraguan government hopes to exert some control over BOSAWAS, and to establish zones appropriate for such diverse activities as settlement, tourism, forestry, agriculture, mining, and subsistence hunting and gathering. It is anticipated that land cover/use maps and a GIS database will permit the delineation and assessment of land areas where conflicts over land ownership/tenure have arisen, or are likely to occur in the years ahead. At this time, a major concern is the extent of deforestation over the last five to ten years.

METHODOLOGY

2.1 Information Sources

Problems with cloud cover have limited the initial selection of satellite images to two Landsat MSS images and a single Landsat TM image acquired in early 1986, and to a single Landsat TM image acquired in January 1995. The latter image covers approximately two-thirds of the study area and suffers from approximately 35 percent cloud cover. Attempts to acquire additional images via EOSAT, SPOT Image Corporation, and RESTEC Japan have met with failure because of cloud cover. Synthetic aperture radar (SAR) images acquired by the ERS-1, -2 and Radarsat programs have been investigated, but spatial resolution is insufficient for thematic classification of land cover/use. At present SPOT

Image is attempting to acquire additional images of the study area, but 48 attempts to-date have been unsuccessful.

Topographic maps of 1:50,000 scale were used to collect ground control, as well as information on hydrography and transportation networks. These maps were produced in 1988 from aerial photographs recorded by the former Soviet Union. Boundaries of indigenous territories were acquired from maps created by anthropologists working with the individual indigenous groups.

2.2 Field Analyses

Field analyses of the area were conducted in July/August 1995 and January/February 1996 to formulate the land cover/use classification scheme. At specific points, coordinates were acquired using a global positioning system (GPS) and photographs were taken to record the land cover/use. Sixty-eight points were located representing a wide variety of land covers.

2.3 Thematic Classification

Abbreviated spectral reflectance curves for various land cover/use categories were produced from the 1995 TM image. These spectral reflectance curves were then matched with similar reflectance curves from the 1986 TM and MSS images. From these curves it was determined that the following land cover/use classes could be determined with a high degree of certainty:

I. Agriculture/grassland
II. Scrub - areas dominated by low woody vegetation
III. Early secondary growth - young trees
IV. Advanced secondary and primary forest
V. Villages

Supervised classification of the images involved TM bands 3, 4 ,5 and 7, and MSS bands 1, 2, 3, and 4. Where villages could not be spectrally distinguished from the surrounding terrain, they were digitized from the topographic maps and registered to the classified images. All data files were rectified to UTM coordinates using control obtained from the 1:50,000 scale topographic maps.

2.4 Digital Database Construction

The raster classification images were then converted to ARC/INFO vector format through on-screen digitizing utilizing the DMS software. All other information required to complete the database were digitized from existing maps. Overlay functions were performed in ARC/INFO to identify the land cover/use changes that occurred between 1986 and 1995.

3. RESULTS

Image analyses reveal that the amount of forest land has decreased during the period 1986 through 1995 in the southern and western portions of the Reserve. In these areas forest is being converted to agricultural land. Most of the conversions are occurring around villages that act as focus points for settlement and along roads and rivers that are the main transportation routes into the reserve. Behind the agricultural frontier, small areas are undergoing natural succession to scrub and early secondary forest.

4. CONCLUSION

This study has shown the feasibility of conducting land cover/use change analyses from remotely sensed imagery as part of a comprehensive plan for the management of tropical forests. The digital database will be provided to the Nicaraguan government and form the foundation of the Reserve's management plan. Its use will enable the placement of realistic boundaries for zones allocated to specific activities.

5. REFERENCES

Bowermaster, J. 1995. Heaven Can Wait. Nature Conservancy, May/June pp. 10-15.

Nietschmann, B. 1990. Conservation by Conflict in Nicaragua. Natural History, 11, pp. 42-48.