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Mapping Mexico's Forest Lands with Advanced Very High Resolution Radiometer

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SUMMARY

Data from the Advanced Very High Resolution Radiometer (AVHRR) were used in a program sponsored by the U.S. Department of Agriculture, Forest Service, and the United Nations Food and Agriculture Organization to help scientists from Mexico generate forest-cover maps of that country. Two near-cloud-free composite images were generated for December and March 1990 from AVHRR Local Area Coverage data sets. A supervised training and classification technique was used to process data in nine physiographic regions of the country. Regional classifications were combined to produce the final map. Classification accuracy for 60 test polygons was 78 percent correct for the polygons and 84 percent correct as evaluated by pixels in selected polygons. More detailed physiographic or ecologic partitioning of the country was cited as a way to improve results of the classification technique used in this study.

INTRODUCTION

Data collected from the Advanced Very High Resolution Radiometer (AVHRR) by polar-orbiting satellites of the National Oceanic and Atmospheric Administration (NOAA) have been used for continental (LeCompte 1989) and even global (Hastings and others 1989) vegetation characterization. Much interest has been placed on use of the Normalized Difference Vegetation Index (NDVI) for depiction of vegetation vigor (greenness). Malingreau and Tucker (1987) discussed uses of AVHRR data for monitoring deforestation in the Amazon River Basin. Other studies have demonstrated uses of AVHRR data for land-cover (Kerber and Schutt 1986) and fire-fuels mapping (McKinley and others 1985).

Application of AVHRR data for forest mapping is growing in scope and interest. Teuber (1988) demonstrated forest-area estimation over a three-State area with AVHRR data. This work was extended by Zhu and Teuber (1991) to include detailed comparisons of changes in forest area derived from two dates of AVHRR and forest inventory surveys of Alabama. Iverson and others (1989) used data from the Landsat TM (thematic mapper) to calibrate percentage of forest cover in AVHRR pixels (picture elements) of the Southeastern United States.

Support is growing for forest monitoring programs in developing countries. The United Nations Food and Agriculture Organization (FAO) is keenly interested in making assessments of changes in tropical forest resources by use of AVHRR imagery. The synoptic coverage and multispectral characteristics of the data make them ideal for large-area mapping and monitoring. Coincident with FAO's forest assessment program, Mexico expressed interest in establishing a periodic forest inventory to keep track of and thereby better manage the country's forest resources. The common interests of FAO and Mexico led them to approach the U.S. Department of Agriculture, Forest Service, about providing AVHRR analysis training to Mexican scientists. Support for this training was provided by the International Forestry Division under the Tropical Forestry Program of the Forest Service.

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The Southern Forest Experiment Station, Forest Inventory and Analysis unit (SOFIA) organized and completed two sessions of instruction in remote sensing with emphasis on AVHRR digital data analysis. Basic instruction on remote sensing principles was provided by the Mississippi State University School of Forest Resources. Hands-on training in AVHRR data processing was provided by SOFIA, which also gave instructional background on forest inventory techniques and data organization. Work described here focuses on the detailed analysis procedures used during these sessions to generate a forest-cover map of Mexico from AVHRR data.

METHODS

Multidate composites of NOAA-i 1 satellite AVHRR data were produced to cover Mexico with a minimum of cloud cover. The primary data set consisted of a three-date composite developed from December 1990 data. A three-date composite of March 1990 data was also used. All satellite data were processed in the ERDAS[1] image processing software system on Sun Microsystems workstations. The final map was prepared by using ARC/INFO geographic information systems (GIS) software.

Field information was supplied in the form of 1 :1 ,OOO,OOO vegetation maps, Landsat TM prints, aerial photographs, and other ancillary maps. The required expertise was provided by the scientists from Mexico who worked on the project.

Image Cornpositing Process

All subject images for each composite were visually compared for overall image quality. A hierarchical approach to image combination and overlay was used to develop each composite. The best images occupied the greatest area in each composite. Only areas within 35 degrees of nadir were used from each image to avoid atmospheric and geometric attenuation of data at extreme scan angles.

Clouds were masked out with zero values in the image data sets. The poorest quality data set represented the bottom layer for each composite. Images were overlaid on each other, so new data then filled in the zero areas of the previous layers. This process was continued until all images had been combined into the final composites. Each composite was subjected to low-pass filtering to smooth obvious transitions between file segments from the separate images used in the cornpositing processes.

An outline of Mexico was digitized in ERDAS and used to extract the image data of the land area in the country. The composites each consisted of five standard AVHRR channels: (1) 580 to 680 nm, (2) 730 to 1,100 nm, (3) 3,500 to 3,900 nm, (4) 10,300 to 11,300 nm, and (5) 11,500 to 12,500 nm, plus an NDVI channel. (NDVI is expressed as the difference between channels 2 and 1 divided by their sum and is an indicator for vegetated land cover.)

Classification

The composite data set for December 1990 was divided into nine physiographic/ecologic regions for Mexico. This was done to partition some of the spectral variance expected to occur between similar cover types in the separate regions. Each region was processed independently; then all regions were recombined to produce a general vegetation map of the country.

A supervised classification approach was used to analyze the data. Ten to 15 training areas were selected from each region to represent the cover types defined for the project: (1) temperate forest, (2) tropical high and medium forest, (3) tropical low (dry) forest, (4) scrublands, (5) desert, (6) irrigated agriculture lands, (7) other unforested lands, (8) water, and (9) clouds. All cover types did not occur within each region and therefore could not be sampled from each region. Sixty test polygons (for accuracy assessments) were selected concurrently during the training process. The test polygons were not used for spectral training. Spectrally nonhomogeneous samples (large channel variance) were discarded and replaced as the training phase proceeded.

[1]Mention of company or brand names of products or services is solely for the reader's information and does not constitute official endorsement by the USDA Forest Service.

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The maximum likelihood algorithm in ERDAS was used to classify each region. All classified regions were then combined into a single file. A map of the country was produced for evaluation by using the ARC/INFO GIS software package. The map was compared to vegetation maps and other ancillary information to identify problems in the initial classification. Additional training samples were identified for problem areas, and the data were reclassifed. Other refinements were provided by using the March 1990 composite data to account for some expected seasonal variance.

Accuracy Assessment

The 60 test polygons, each 60 to 100 pixels in size, were used in two accuracy assessment techniques to evaluate the classification map. One test compared the predetermined category of each polygon to the majority category derived for each polygon from the classification. Overall percentage of accuracy for this method was expressed as correct polygons divided by 60, then multiplied by 100.

The second test compared all polygon pixels in the classification map to those in the test polygons. Thus, the percentage of accuracy was calculated as total correct pixels divided by total test pixels, multiplied by 100.

RESULTS

Comparison of the map in figure 1 to vegetation maps and Landsat TM prints indicated a good general correspondence for the cover types that were identified in the study. The accuracy of this map was 78 percent as tested by the polygon comparison method. The pixel comparison method yielded an accuracy of 84 percent. The higher accuracy by the pixel method was probably due to correct pixel classifications within otherwise incorrect polygons.

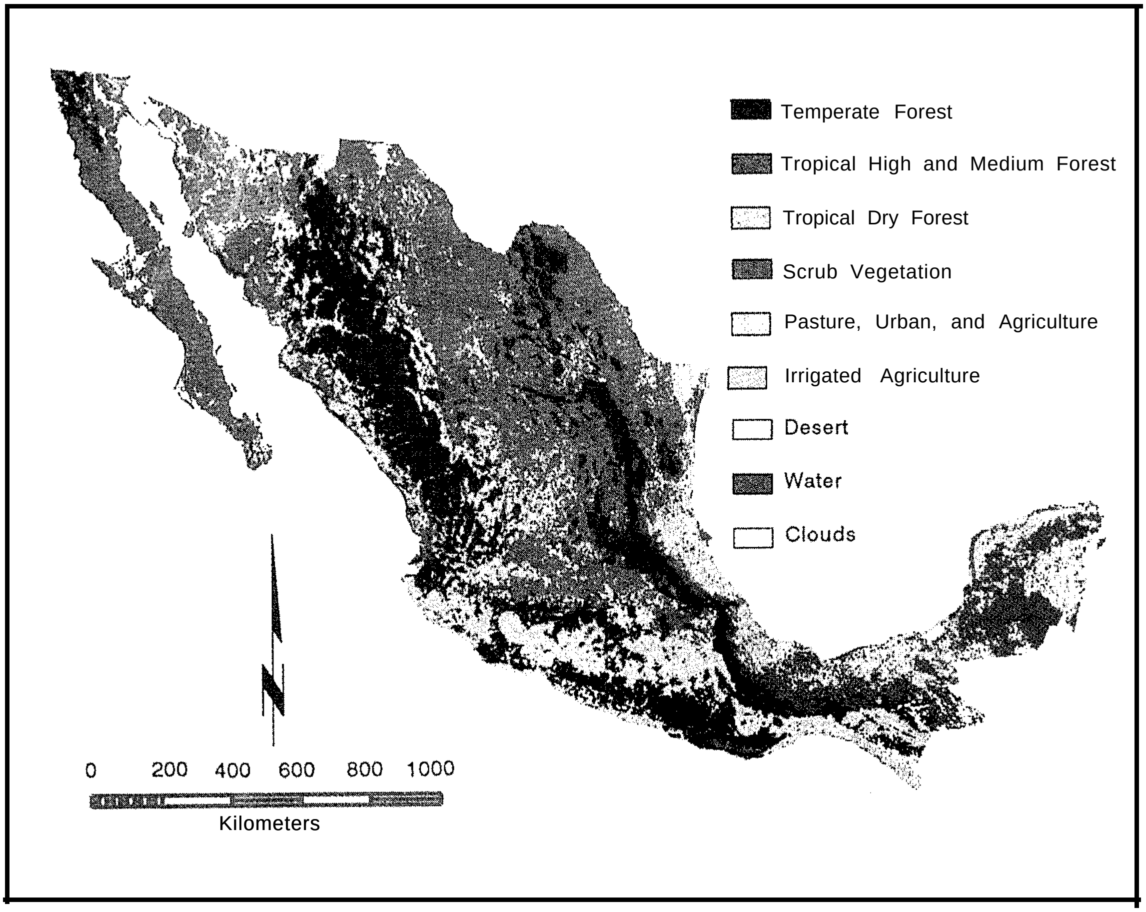

Figure 1. *General forest classification of Mexico from Advanced Very High Resolution (AVHRR) data (preliminary version).*

Many obvious classification errors were identified as problems of inadequate sampling in the first training phase of the project. These errors were corrected by additional sampling, particularly near the edges of the physiographic regions where spectral variation in vegetation was expected to occur. All scientists involved in the project agreed that some confusion would be eliminated by partitioning the country into more distinct zones of ecologic diversity before training and classification begin.

FUTURE CONSIDERATIONS

The current map will undergo additional review in Mexico and then will be refined based on additional field verification and Landsat data. Additional data sets will further define seasonal and zonal variations in the wide range of ecologic settings that exist in Mexico. Scientists from both Mexico and SOFIA anticipate that remote sensing products such as the classification map will help form the basis for the nationwide forest inventory programs of Mexico.

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