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Site-specific evaluation of protected and non-protected forest stands in the Dominican Republic using GIS & Remote Sensing

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Abstract
The Dominican Republic is a mountainous Caribbean country where forests are ecologically and economically very important. However, the forest cover is declining and information about the forests of the Dominican Republic is scarce.
In this project, medium to high resolution remote sensing data (e.g. Landsat TM & ETM, IRS, IKONOS, hyperspectral), topographic information (DEMs) and ground data (e.g. ASD FieldSpec) are to be used to extract information about forest cover, forest types and properties of protected and non-protected forest stands. Test sites will be located in mountainous regions of the central and south-western Dominican Republic. The aim is the development of an operational method for tropical mountain forest mapping. The resulting information is to be integrated in a geographic information system (GIS), facilitating information accessibility. The project is integrated in PROCARYN (Proyecto Manejo y Conservación de la Cuenca Alta del Rio Yaque del Norte), which is financed by the KfW (Kreditanstalt für Wiederaufbau).

Introduction
Research projects on the ecology of the Dominican Republic, especially in regard to forests and hydrology, are in preparation at the Department of Geography of the University of Göttingen. Cooperations have been established with the Department of Geography of the University of Mainz and the PROCARYN (Proyecto Manejo y Conservación de la Cuenca Alta del Rio Yaque del Norte), which is a project of the GTZ (Gesellschaft für technische Zusammenarbeit), the KfW (Kreditanstalt für Wiederaufbau), the DED (Deutscher Entwicklungsdienst) and the SEMARENA (Ministry of the Environment of the Dominican Republic).
The Dominican Republic is situated at the margin of the tropics with trade winds determining for the regional climatic conditions. The country is dominated by mountain ridges with heights of up to 3175 m. Accordingly, there is a large variety of climatic conditions and natural habitats. The natural vegetation consists mainly of a variety of forest types, and in 1930, approximately 75 % of the country were still covered with forests (Casanova 1998). Although deforestation in the Dominican Republic is not as complete as in neighbouring Haiti, the country has since lost considerable parts of its forests, reducing the forest cover to roughly 27 % (Tolentino and Peña 1998), much of

which is already degraded. According to May (1997) more than half of the country is only suited for forest use because of steep slopes. The forest reduction and degradation in these areas causes severe erosion and sedimentation of water reservoirs. Besides, the mountain forests of the island play an important role in regulating the water balance of the island's rivers, which originate in the mountains and provide the towns and agricultural areas in the basins with water (Kappas 1999). To protect the remaining forest areas, tree-cutting is prohibited in the whole country since 1967, but this did not prevent the forest from declining through forest fires, shifting cultivation, charcoal burning and overgrazing (Bolay 1997). The conservation of protected forest stands and the introduction of sustainable forest management practices including agroforestry which also consider the interest of the local population would be very important, but the necessary precise information about the present state of the concerned areas is not available.

The aim of this project is to map the extent and properties of protected and non-protected forest stands (and scattered groups of trees) using GIS & remote sensing methods and to make the attained information accessible via a GIS system. Main test sites will be located in the upper catchment area of the Rio Yaque del Norte (Cordillera Central) and in the south-western Dominican Republic (Sierra de Baoruco) (see Fig. 1).

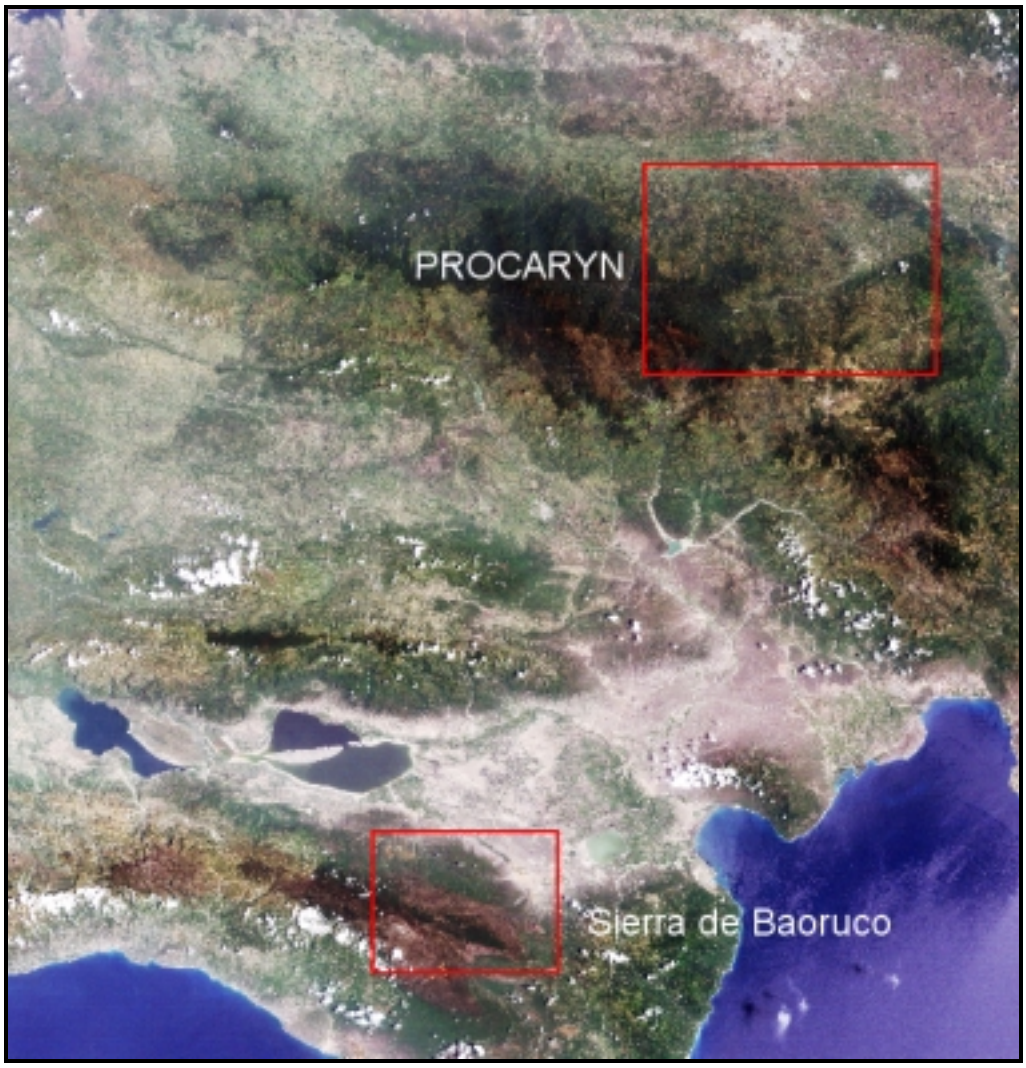

Figure 1: Landsat 7 ETM image (RGB=321) of the central to south-western Dominican Republic with locations of the main study areas.

Materials and Methods

Data

Medium to high resolution remote sensing data, topographic information and ground data are going to be used. Remotely sensed data already acquired include a Landsat 7 scene (Path 08, Row 47) of September 2000, which covers all test sites, and IKONOS data (multispectral bands with 4 m and panchromatic band with 1 m spatial resolution) for a part of the catchment area of the Rio Yaque del Norte. For multi-temporal comparisons, Landsat TM data can be used. Additional satellite data like IRS may be included. Aerial photographs and hyperspectral data are also going to be acquired. Ground truthing will be supported by radiance measurements with an ASD FieldSpec ® field spectrometer to establish a spectral library of tropical vegetation species. Digital elevation models (DEM) with a horizontal resolution of 50 m have been compiled from 1:50,000 topographic maps. Radar (e.g. SRTM, shuttle radar topography mission) data may give additional elevation information (e.g. about the canopy surface of dense vegetation) while on the other hand, the existing map-based DTM can be used to validate the SRTM-data. Also planned are laser altimetry measurements.

Methods

Image processing of the remotely sensed data is going to include geometric and radiometric corrections. The correction of topographic effects, geometric as well as radiometric, is going to be important in the mountainous study areas (Tokola et al. 2001). For this purpose, a good DEM will be essential. Only after these pre-processing steps will it make sense to classify the data. Ancillary data (topographical information, soil maps, botanical or forestry ground data from the test sites, etc.) are going to be integrated in the classification process. Digital elevation models are going to be used to extract terrain parameters (slope, aspect, curvature, catchment area, wetness indices), particularly with regard to hydrological modelling, but also as ancillary data in the forest classification process. Object-oriented image processing methods (eCognition) are going to help record small-scale land use patterns.

Laser altimetry measurements can be used to extract forest inventory parameters like canopy height (by first pulse/last pulse measurements) and crown cover, also giving a more detailed view of the ground surface (Tickle et al. 1998). Canopy height profiles will also be helpful to differentiate between primary forests and reforested areas. It remains to be seen how many additional forest inventory parameters (e.g. biomass, stem volume, LAI, species/biodiversity, forest density) can be extracted from remote sensing data for a better description of tropical mountain forest stands.

Combining the data and the methods which turn out to be best suited for this purpose, an operational method for multi-scale tropical mountain forest mapping is going to be developed.

GIS

The existing geographic information and the information gained through image processing are to be integrated in a geographic information system (GIS). The GIS is going to help analyse the data in the context of the various information layers. When all necessary parameters are integrated, it can also be for hydrologic modelling. Besides, the GIS is going to be used as a mapmaking tool, facilitating information accessibility.

Discussion

As the project is still at an early stage, no final results can be presented yet. However, the good availability of traditional and new remote sensing data of high spectral and spatial resolution and of ground data through contacts to scientists working locally are a promising basis for the ongoing research.

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