SPECIES DISTRIBUTION AND FOREST TYPE MAPPING IN MEXICO

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1. ABSTRACT

In recent years, the increasing availability of earth observation data at different spatial and temporal resolutions together with an increasing number of digitized and geo-referenced species occurrence data (museum and herbarium collections as well as field observations) has created the opportunity to model and monitor species geographic distribution and richness on regional to global scales. Nowadays, predictive species distribution modeling is urgently needed with respect to the observed climate-induced and anthropogenic land cover changes, decreasing environmental stability, and continued biodiversity loss. Furthermore it has become a key element in documenting biodiversity and identifying conservation priorities [2].

Existing studies on the explanatory power of remote sensing data for species distribution patterns can be categorized into three types [1]: (1) Direct mapping of individuals or associations of single species in spatially contiguous units, (2) Mapping of habitats using remotely sensed data and predicting species distributions based on habitat requirements, and (3) Investigations of direct relationships between spectral radiance values recorded from remote sensors and species distribution patterns based on field observations.

Still, the combination of parameters derived from remote sensing data with the algorithms of species distribution models is in the fledgling stages. Most traditional modeling studies use only climate and topography data as environmental predictors and may thus produce inaccurate predictions since important niche limiting factors are not considered in the input data. Recent studies started to incorporate land cover information in the modeling process [3] [4], but the causal relationships between the categorical variable land cover and species distributions are often indirect and consequently not easy to detect by statistical algorithms. Several novel analytical techniques have been developed that more fully exploit the ecological information of multi-temporal remotely sensed imagery beyond land cover classification applications. Especially phenological characteristics (e.g. the starting date and length of the growing season) may provide useful ecosystem characteristics that explain the actual rather than the potential (when solely employing climate variables) spatial distribution of plant species [5].

In this context, the study explored the potential of multi-temporal Terra-MODIS data for modeling the geographic distributions of selected plant species in Mexico. The mega-diverse country of Mexico, which maintains around 10% of the world's biota, was selected due to its significant floristic richness as a result of geologic, physiographic, and climatic variations throughout the country. This diversity is complemented by mingling flora and fauna from both, tropical South America and temperate North America. The species occurrence data used within this study was kindly provided by the National Commission for the Knowledge and Use of Biodiversity (CONABIO) of Mexico.

The following environmental predictors were used with the Maxent modeling algorithm ([6] [7] and [8]) in a variety of combinations: (1) phenological metrics (Table 1) derived from the 16-day 1km vegetation indices Terra-MODIS product (MOD13A2) and averaged over the seven years of the study period (2001-2007); (2) topographic data including elevation,

slope, and aspect of the SRTM mission; and (3) a series of bioclimatic variables (WorldClim, [9]) derived from monthly temperature and rainfall values. The different model scenarios were compared on the basis of independent species occurrence data by omission and commission rates and AUC statistics (area under the *receiver operating characteristics* ROC curve). The areas predicted with and without remote sensing data were contrasted and determining factors were identified using auxiliary data and information sources.

Table 1: Extraction of time series features and their ecological interpretation derived from MOD13A2 data.

Dataset	Spatial resolution	Time period	Information content / Ecological interpretation
Annual maximum	1 km	2001-2007	Maximum amount and density of green biomass
Annual minimum	1 km	2001-2007	Minimum amount and density of green biomass, detects irrigated, agricultural areas and urban settlements
Annual mean	1 km	2001-2007	Integrated measure of annually produced green biomass
Annual range	1 km	2001-2007	Annual increase of green vegetation
Annual standard deviation	1 km	2001-2007	Related to shape of the time series curve
Date of maximum	1 km	2001-2007	Time of vegetation (density and greenness) maximum
Date of minimum	1 km	2001-2007	Time of vegetation (density and greenness) minimum

Model predictions of several representative key species can be combined and further interpreted as approximate vegetation type predictions and proxy indicators for land cover maps. Even though developed for the biodiversity hotspot Mexico the presented methods can be transferred to any study region on the globe depending only on the availability of reliable geo-referenced species occurrence data from field observations or museum/herbarium collections.

The improved distribution maps significantly contribute to sustainable long-term conservation planning and management of biodiversity hotspots. Altogether, we see the contributions of remote sensing data to species distribution modeling especially in the improvement of spatial and temporal resolution and by adding new dimensions of environmental variables and ecological parameters. Further systematic research is required to fully investigate the potential and limitations of remote sensing data in this context.

2. KEYWORDS

Species distribution model, Habitat mapping, Multi-temporal analysis, Time series, MODIS, Phenology

3. REFERENCES

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