Machine-based Determination of Conservation in Mexico

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Abstract

Conservation efforts in the state of Veracruz, Mexico, are supported by the geographical information system, BIOCLIMAS. In addition to its original use in study of climatic parameters as related to plant geography, it has recently been adapted to the semiautomatic determination of degree of conservation of natural areas, producing an "Ecological Landscape Modification Map" ("Mapa de Modificaciones Ecológico-Paisajísticas"). The method, first applied to the state of Veracruz (73 000 km^2), is based on machine interpretation of information from available maps at 1:1,000,000 and produces an evaluation on a scale from 1 (very well conserved) to 8 (completely changed from natural state). The method is soon to be applied to a much larger area of the country, and eventually will be used for the whole country (2 000 000 km^2) A disadvantage of the method is its use of maps made in the past; it can only be as accurate as are its source maps, some of which in Mexico are a decade old. Aside from its general use in evaluating the conservation of large areas, it is being used to evaluate existing reserve areas and planning for new reserves.

Keywords

Degree of conservation, landscape ecology, landscape modification, Mexico

1 INTRODUCTION

There is vital need of information to support officials charged with conservation of the environment, as well as general information that can be understood by the general public. The development described here produces maps that show the current state of conservation of the environment. In addition to being very useful for conservation authorities, they are also easily comprehensible to the general public.

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2 PREVIOUS WORK

BIOCLIMAS (Soto *et al. 1984,* Soto, Giddings and Gómez 1996, Giddings, Soto and Ronzón 1996.) is a simple raster-based geographical information system (GIS) that was created to support research in plant geography in the state of Veracruz in Mexico. Veracruz (fig. 1) is a large state that spans nearly six degrees of latitude, sea level to the highest point in Mexico, and includes all but the most arid of Mexico's climate zones. With an important history of botanical studies dating back over a century, and with important tropical forest resources, it was selected as an area for concentrated studies in 1967, in an umbrella project called "Flora of Veracruz" (Gómez-Pompa and Nevling 1970), covering detailed botanical studies in taxonomy, plant distribution, plant geography, pollen, and others. BIOCLIMAS has been used to produce bioclimatic fascicules, such as the one on the Betulaceae family (Soto and Gómez-Pompa 1990), and it is also used as a source for general information on the climatology of Veracruz (Soto and García 1989).

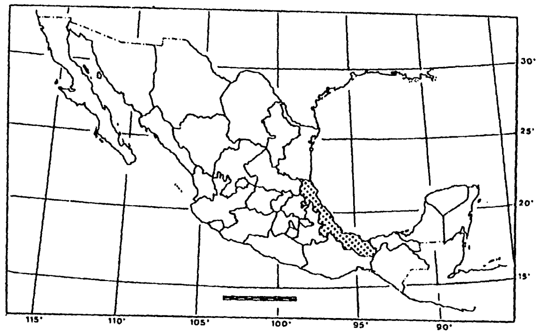

Figure 1: Location of Veracruz in Mexico

The project early included studies relating climate to plant distribution. The state has a rather dense network of several hundred meteorological stations, all but a few operated by persons without training. Data from these stations were collected manually and managed by primitive computer programs in the early years of the project, starting around 1967. The combined data, converted to seventeen climatic parameters, were plotted as maps on transparencies, but converted to a GIS in 1982. Since then the system has migrated through several computer systems and now resides on PCs. Its software was specialized in handling point of observation of individual plants and sets of plants, deriving the range of each climatic variable, and then demonstrating the area in the state which had the same range of the chosen climatic parameters. This area might be considered a potential area of distribution of the plant.

Predicted potential areas are certainly subject to many non-climatic restrictions, such as soil conditions and human activities. Perhaps most important is the degree of conservation of the area. In the extreme cases of intensive pastures and monocultures of crop plants, or areas strongly changed by urbanization or industrialization, there would certainly be little possibility of occurrences of such plants. State of conservation is evidently a factor which would affect the potential area of distribution of a given plant.

3 THE NON-AUTOMATED METHOD

The method chosen for calculation of the state of conservation had its roots in work in Cuba (Chiappy *et al.* 1989). Groups of specialists were mobilized to study the current environment of proposed areas, and to predict the effect of tourist development. Concurrent studies were made of the plants, animals, landforms, and others. As a byproduct of these studies, it was evidently feasible to systematize the prediction of the current state of conservation, based on a variety of factors. The relevant matrices were published in the reports of these studies.

The area of the largest of the Cuban islands was 777 km^2, for which it was reasonable to mobilize groups of specialists in intensive studies. When the chance came to apply the same procedure to the state of Veracruz, 73,000 km^2, it was obviously impractical to perform such studies *in situ*. Instead, the decision was made to derive information from existing maps published by the national mapping agency of Mexico, INEGI (Instituto Nacional de Estadística, Geografía e Informática). Here field work would be used to confirm results.

This new method was still manual. Maps available for the state came from the collection called Geographical Synthesis of Mexico (INEGI 1988), all at a scale of 1:1,000,000, including maps of Climate, Soils, Physiographic Region, and Vegetation and Land Use; maps of Potential for Forest Use, Potential for Cattle Use, and Agricultural Potential were used only for corroboration and resolving problems. The maps were chosen not because they were ideal for the problem but because they were available and the information could be derived from them. There are certainly other combinations of maps that could be used.

A new matrix was developed to use information available on these maps. The maps were overlaid as transparencies, and a single person (Chiappy) derived the degree of modification by applying the matrix and hand drawing the resulting regions on the output map.

The result was a map with the first six degrees presented in table 1 (1: "very well conserved" to 6: "very strongly altered"). The map was formally called the "Ecological Landscape Modification Map of the State of Veracruz" (Mapa de Modificaciones Ecológico-Paisajísticas del Estado de Veracruz). Local conservation experts were very pleased with the result and considered the results to be quite accurate (they assigned a value of 80%, adequate for their work and better than any other procedure currently available).

Table 1: Degrees of Modification of Ecological Landscapes

Class	Degree of modification	Explanation	% of area
1	scarcely modified	Areas in which landscapes maintain their components and attributes in a natural stage or very close to them.	11
2	weakly modified	Landscapes with slight modifications, especially in their biotic components, such as vegetation. The only modifications are due to natural processes acting without human intervention.	10
3	partially modified	These are areas in which landscapes have suffered alteration of some of natural components, such as flora, due to human activities (such as forestry) but maintain most of their primary characteristics. They can recover if left alone.	10
4	moderately altered	In these areas, landscapes have suffered a transformation of biotic components giving secondary communities, such as occurs with slash and burn agriculture.	7
5	strongly altered	Landscapes where natural ecosystems have been have been changed to a greater extent, such as in traditional agroecosystems without mechanization.	9
6	very strongly altered	Areas in which all the natural and secondary ecosystems have been changed, such as by highly mechanized agriculture.	53
7; 8	drastically altered; human landscapes	In these areas, landscapes have suffered strong and irreversible alteration. Human activities have altered some their more stable and invariant components, such as relief and climate. Typically, these are urban and industrial areas.	>1

The fact that a single person could produce a map in this fashion demonstrated the feasibility of the method. Still, this was evidently a procedure that should be better formulated and somehow automated. The prospect of applying the procedure to larger areas or to the whole country (2 000 000 km^2) required some kind of automation of the system.

4 DEVELOPMENT OF THE AUTOMATED PROCEDURE

For the automation, the source maps were digitalized using the ILWIS program (1992), and then converted to raster for use within BIOCLIMAS. A module for BIOCLIMAS was developed to convert input raster geographical data into output raster data on the basis of defined matrices.

The processing power of the human mind allowed a person to consider the categories of the transformation matrix and produce output categories. Still, the sheer number of categories and possible combinations suggested intermediate steps in the computer, especially for human control of the system. The intermediate products chosen were Potential for Erosion, Soil Fertility, and Forms of Land Management. Matrices were used to produce these from input map classes. A fourth matrix was used to produce degree of conservation from these data. Details of the matrices used are presented in separate reports (Giddings *et al.* 1996, Chiappy *et al.* 1996). Here we will simply comment on the use of these matrices.

The Potential for Erosion

This map was developed from information on soils, landforms, and maximum precipitation (an existing parameter in the BIOCLIMAS) GIS. The soils were classified according to their susceptibility to erosion; the landforms were classified into three types according to their susceptibility for erosion, and the maximum precipitation was divided into seven classes, from less than 20 to more than 100 mm per day. The matrix converted these classes into one of six categories of susceptibility to erosion, from "not susceptible" to "very susceptible."

Soil Fertility

Since fertility controls many uses of the land, it is obviously a factor that is key to its conservation. The fertility map, with four classes ("none," "slight," "moderate," and "fertile") was derived from the two maps, Soils, and Superficial Hydrology. It was necessary to include information on superficial hydrology ("saline soils," "alkaline soils," "saline/alkaline soils," and "flooding zones") for their information on the different natural processes which operate on soil subunits. For example, a unit which is considered fertile could present various problems if found in an area affected by salinization or flooding.

Forms of Land Management

Different uses of an area cause modifications of the soil and subsoil. The Vegetation and Land Use maps presented the classes: "primary vegetation," "secondary vegetation," "mixed agriculture with secondary vegetation," "agriculture," "induced pasture," "cultivated pasture," "mixed agriculture with induced pasture," "mixed agriculture with cultivated pasture," "areas without vegetation," and "areas of strong erosion." The matrix combined these with information from the map of Capacity for Agriculture Use and others to form a map with only six classes.

Map of Degree of Modification

A matrix with classes of the three maps above yields six classes of modification, as in the manual method. A further division of the most altered areas was made on the basis of urbanization and industrialization information from the other maps, yielding the final map, reproduced in abbreviated form in Table 1 presents the definition of each class and the area of the state corresponding to each class.

5 DISCUSSION

Presented here is the state of the technology when this report was written (February, 1997). The process will continue to be refined in many ways, especially as it is extended to larger regions. It is currently scheduled to be applied to the northwest part of Mexico, to include the states of Baja California Norte, Baja California Sur, Sonora and Chihuahua.

The automated map of the state of Veracruz shows more detail than the hand-made map, as is to be expected. The automated process functions pixel by pixel, as it should, whereas a person simply cannot advance in this way. The authorities involved in conservation in the state are more pleased with this version than with the manual version.

Several parts of the procedure will be changed in the future. The selection of maps used is strictly based on the availability of information in a form suitable for the automation process. When other forms of information are available, they may well be used. As an example, the derivation of information on Potential for Erosion would profit from digital slope maps. The digital terrain images of the whole country (INEGI 1994) were not available in time for this project, but will probably be used in future applications, especially for slope data for erosion potential. Likewise the manner of including information on urbanization to distinguish the least conserved zones will also probably change.

A fundamental problem with these degree of conservation maps is that they can only be as good as the source maps. The source maps used here were not completely up to date, and so the conservation information cannot be complete. To a certain extent this problem can never disappear. Still, it is evident that the automation of the process makes updating the system much easier.

There are many applications for this type of map. In the case of Veracruz, it is helping evaluate actual reserve areas, and helping the decision-making process of where new reserves may be established. In studies of plant geography, the information is pertinent to studies of potential distribution of plants predicted on the basis of climatic parameters. It will also be used for studying corridors between well conserved areas. It is also being studied as a base parameter for environmental impact studies.

Still, perhaps the most important use is for unspecialized government officials and for the public in general. In spite of the great public interest in conservation in Mexico, the unspecialized public really has very little knowledge of the subject. The fact that this aspect of conservation can be shown in an attractive and understandable document will help public support. Additionally, presenting quantitative information that can readily be understood, as in table 1, helps the public to understand the very real problems involved in conserving the environment. It is interesting to note that 30% of the state could revert to nearly its original ecological landscape if allowed.

6 CONCLUSIONS

We have presented a method currently in use to prepare a map which shows the degree of conservation of all points of a large area. It can be used wherever sufficient information is available in thematic maps, as they are in Mexico. The products are useful to specialists and to conservation officials. They are also easily understood by the general public, and as such, can support informed public support of conservation issues.

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