MEASUREMENT OF DEFORESTED AREAS BY IMAGE PROCESSING TECHNIQUE
A METHODOLOGICAL STUDY

Konrad Grosser
Institute of Geography and Geoeology
of the Academy of Sciences
Dimitroffplatz 1
Leipzig
7010
DDR / Alemanha Oriental

ABSTRACT

A technique of area measurement by mask scanning and image
processing is discussed. The efficiency of this technique is
compared with the conventional technique of grid-square count-
ing. The techniques were applied to masks stemming from a
deforestation mapping project.

1. INTRODUCTION

Recently, the first phases of two
mapping projects on deforestation in
Brazil have been finished:
- Alteration of the forest cover in
  Legal Amazonia
  (Ateração da cobertura florestal na
  Amazônia Legal; INPE / FUNCATE)
  [1].
- Atlas of the Atlantic Forest
  (Atlas Mata Atlântica; S.O.S. Mata
  Atlântica / INPE / IBAMA / Image /
  Sensora) [2].

In both projects the areas of
interest were detected by the visual
interpretation of colour composites of
Landsat TM 5 data. The results of the
interpretation (deforested areas in
Amazonia or the rests of the Atlantic
Forest) are represented on the base of
topographic maps.

One of the main objectives of
both projects consisted in the deter-
mination of the total area (deforested
or still covered, respectively). This
step was performed by conventional
techniques or manual digitizing. These
techniques are relatively time-consum-
ing. Therefore an alternative techni-
que was suggested and tested using the
FEAG scanner and an image processing
system [3]. In this paper the used
technique is discussed with special
regard to its efficiency and accuracy
compared with the conventional techni-
que of grid-square counting.

2. SAMPLES USED IN THE STUDY

A) a film copy of the thematic overlay
for the map sheet Rio Branco (SC
20-Z-B) reduced to an approximate
scale of 1 : 550 000,

B) a mask of the deforested area in-
terpreted on the basis of the
Landsat TM image 002/087, 26/07/88,
approximate scale 1 : 845 000.
The interpretation was done on the
KARTOFLEX [4] using a 6cm by 6cm
colour slide. The image was
divided into four sections for
rectification.

The samples are represented
in Figure 1 and Figure 2 reduced to
1 : 4 000 000.

3. AREA MEASUREMENT BY THE CONVENTIONAL TECHNIQUE

Grid-square counting is a conven-
tional technique of area measurement.
It was used for comparison with the
results of scanning. The grid squares
Figure 1: Thematic overlay (SC 20-2-B) reduced to 1 : 4 000 000

Figure 2: Mask of the interpreted area in TM-image 002/087 reduced to 1 : 4 000 000

had a size of 1mm by 1mm (i.e. 0.3 sq.km or 0.4 sq.km in nature). In order to reduce possible subjective errors the area was calculated twice: first in the positive film and second in the negative film. The results of this technique are represented in Table 1.

4. AREA MEASUREMENT BY SCANNING AND IMAGE PROCESSING

In order to have a relative small film format of the FEGA scanner of 70mm x 91 ... 93mm [3], both original films were reduced by photographic procedures to a scale of approximate 1 : 4 000 000 (see Fig.1 and Fig.2).

Table 1: Measurements by counting

<table>
<thead>
<tr>
<th>sample</th>
<th>pos. film</th>
<th>neg. film</th>
<th>mean</th>
<th>neg./pos.</th>
<th>time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>sq.mm</td>
<td>sq.mm</td>
<td>sq.mm</td>
<td>%</td>
<td>in minutes</td>
</tr>
<tr>
<td>A</td>
<td>1657</td>
<td>1720</td>
<td>1688.5</td>
<td>103.8</td>
<td>54</td>
</tr>
<tr>
<td>B</td>
<td>8103</td>
<td>8627</td>
<td>8365</td>
<td>106.5</td>
<td>270</td>
</tr>
</tbody>
</table>

The difference in area measured in the positive and in the negative film leads to the assumption that solid black areas are somewhat underestimated by eyes. This phenomena was not subject of the study but it has to be taken into account when the technique is used only for positive copies. The further discussion is only related to the mean values. (see Table 1)

Sample A was reduced to 13.82 %, sample B was reduced to 16.32 %.

The reduced films were scanned with a raster size of 40 μm, i.e. one pixel represents an area of 2.5 hectares in nature. The accuracy of the interpretation and the preparation of the cartographic originals are not discussed in this paper. The results of mask scanning are represented in Table 2.

Table 2: Measurements by scanning

<table>
<thead>
<tr>
<th>sample</th>
<th>number of black pixels</th>
<th>black area (total)</th>
<th>total time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>sq.mm</td>
<td>sq.mm</td>
<td>in hours</td>
</tr>
<tr>
<td>A</td>
<td>18 794</td>
<td>30.1</td>
<td>&lt; 2</td>
</tr>
<tr>
<td>B</td>
<td>163 073</td>
<td>260.9</td>
<td></td>
</tr>
</tbody>
</table>
The scanning and the image processing were done within two hours, including all preparations, explanations, and discussions connected with a pilot experiment. The scanning of one film took 2 to 3 minutes. The calculation of the number of pixels (histogram) is a very simple function in image processing and was done in a few minutes.

5. COMPARISON OF THE RESULTS

Table 3 shows the results converted to the scale 1 : 4 000 000.

<table>
<thead>
<tr>
<th>sample</th>
<th>grid square counting (sq. mm)</th>
<th>scan / image proc. (sq. mm)</th>
<th>difference, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>32.2</td>
<td>30.1</td>
<td>-6.5</td>
</tr>
<tr>
<td>B</td>
<td>220.3</td>
<td>260.9</td>
<td>+18.4</td>
</tr>
</tbody>
</table>

At first glance the results of the techniques used differ considerably. They are even contradictory. These differences can only be explained by the quality of the originals and the reduced films. Regarding sample A, it is assumed that the screen of the original film has influenced the edges of the areas. This influence was not noticed with optical enlargement. With the sample B, a synoptical comparison of the original and the reduced film by means of the KARTOFLEX showed that the photographic process did affect the edges. Optical dispersion and photographic development closed gaps and made little white areas in a black environment disappear.

Comparing the time needed for measuring the areas it becomes obvious that scanning is not much faster than counting if the area in the map sheet is relatively small (sample A) because of the additional time spent in photographic laboratory. If there is a lot of complicated areas in the map sheet the conventional technique takes much more time than scanning. The resolution of scanning was 3 to 4 times higher than that of the conventional technique.

6. CONCLUSION

Each technique of area measurement involves errors. It is a general aim to minimize errors and to be quick. On the basis of the preliminary results of this study some conclusions can be drawn.

Using a scanner, it is possible to eliminate human errors, both systematic (underestimation) and random ones. However, for the development of a fast technique of area measurement by mask scanning it is necessary to consider some crucial points not immediately connected with scanning and image processing but with the photographic process. If it is difficult to control the photographic process, the scale of the reduced film must be larger than in the experiment described. It is supposed that a scale of 1 : 2 000 000 would produce satisfactory results in this special case. The increase in scanning and computing time for larger films is not important with regard to the whole technological process.

Scanning is advantageous for map sheets displaying large and complicated areas. Moreover, the data digitized by mask scanning can be stored easily in a data bank for monitoring deforestation both in Amazonia and in the region of the Atlantic Forest.

The author believes that the technique of mask scanning of visually interpreted areas is efficient until the interpretation for large regions, e.g. the whole Amazonia, can be done completely with the help of image processing systems.

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LITERATURE

[1] especial, ano XVIII, No. 73, Instituto de Pesquisas Espaciais, Junho de 1989


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