

A METHOD FOR URBAN GROWTH EVALUATION USING LANDSAT DATA

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ABSTRACT

The Brazilian towns show accelerated but disorganized growth. The difficulties to obtain precise and updated information about the urban environment as well the growth pattern prevent an efficient control of this process. Orbital remote sensing made possible the realization of the fast and low cost monitoring of the urban evaluation principally after the launching of the Landsat. The objective of this work is to verify the urban growth of one middle size city of São Paulo State, Brazil, using digital image processing of Landsat data. For this purpose a multidate image was generated with a merging algorithm. Multidate color composites allowed the quick verification of the growing areas in the analysed period. The superposition of these informations on topographic maps and municipal land use maps permits the evaluation of the fitness of this urban growth pattern to these environmental constraints.

1. INTRODUCTION

The lack of information on urban growth trends is a major problem for the urban planning process. The conventional techniques which include in situ and/or air-photo surveys are costly and time consuming, what make them unsuitable to the Brazilian condition. A reasonable alternative to this problem is the application of multidate satellite data (Eyton, 1983).

Digital registration of multidate Landsat MSS data proved to be useful to monitor Brasilia (Goias state/Brazil) city growth (Oliveira et alii 1984). By combining both appropriate color filters and date that technique produces color composites in which specific colors are related to different rates of urban growth at given time intervals.

The purpose of this study is to verify the urban growth of São José dos Campos (São Paulo state/Brazil) using digital processing of Landsat data. São José dos Campos underwent an expressive and dynamic growth rate as can be seen in Table 1.

So consequences and changes which occurred in the spatial structure to absorb the intensive demographic growth of São José dos Campos over the period 1977/1984 are also pursued.

TABLE 1

POPULATION GROWTH OF SÃO JOSÉ DOS CAMPOS MUNICIPALITY

DATE	INHABITANT(S)
1950	25.892
1960	55.349
1970	130.118
1980	268.073

Source: FIBGE (1954, 1962, 1973 and 1981).

2. PROCEDURE

Landsat overpass of 31 January 1978 and 13 January 1984 were used. Problems resulting from seasonal variation and target illumination were minimized by selecting data at the same season.

Because of the great spectral separability between urban and rural area during the rainy season this period is recommended for urban growth monitoring. At that time the vegetation is healthier causing a better distinction between urban targets and the surroundings. Crops located in the rural urban fringe are in the growing season, with dense green biomass what improves urban area/non urban area separability.

São José dos Campos, urban growth was only analysed during the period from 1978/1984 because the previous periods had already been studied (Foresti, 1978) using visually registered MSS data.

The data analysis was carried out using Image-100 and visual interpretation following the steps:

- 1) digital enlargement of MSS band 5 up to scale of 1:100.000;
- 2) merging of image pair (1978 and 1984) using Image Registration Program;
- 3) association of the primary colors (blue, green and red to the different dates;
- 4) acquisition of multidate color composite;
- 5) identification of change areas;
- 6) mapping of urban growth areas;
- 7) ground-truth investigation.

Through the Image Registration Program the Image-100 superposes multidate images and performs the necessary geometrical transformations to correct the difference between them in order to coincide the corresponding picture elements (pixels). Through the use of this program and of appropriate color filters (primary color available at I-100) a multidate color composite was obtained.

The color composite related to the merging of two images was obtained associating the blue and green (cyan) colors to the former image (1978) and red color to the latter image (1984) of the pair. The resulting composite exhibits different colors where changes have occurred and gray tones in the areas not submitted to changes (Eyton, 1983).

The cyan represents areas in which the changes were from a high to a low value of target reflectance between dates. In that case bare soil was substituted by vegetation. The red areas correspond to changes from low to high values of target reflectance, which are related to the substitution of vegetation for bare soil or urban area. So the light red areas showed in the composition correspond to urban growth.

3. RESULTS

The analysis of the multidate color composites, (resulting by merging the 1978 and 1984 images) allows the evaluation of São José dos Campos's urban growth and its spatial distribution.

Figure 1 shows the urban growth of São José dos Campos during the period of analysis. The areas kept urbanized are indicated with lighter gray values while the growth areas (built up urban areas) are associated with red color. It was also noted that bare soil for housing estates and/or industrial settlement and sand quarries appear in red colors which correspond to the substitution of dark gray by light gray level areas. In all these case the vegetation was replaced by built areas or disturbed natural areas.

The integration of TM, ground truth and census data lead to classify the changes in the São José dos Campos urban area into six categories as discribed in Figure 1.

The majority of change areas corresponds to new housing estates indicated by number 1 in Figure 1. As an example it can be mentioned the following housing estates: Jardim São Leopoldo (1.10) Parque Santos Dumond (1.9) and São Judas Tadeu (1.12).

It was observed (Alto de Santana 2.8 and Urbanova 2.9) the tendency of urban growth toward the west and northwest regions of the city through the emergence of embankment areas for new housing estates.

Crowding residential areas corresponds to that areas where new residences are built within the urban environment. Those areas are represented by red light spots (Figure 1).

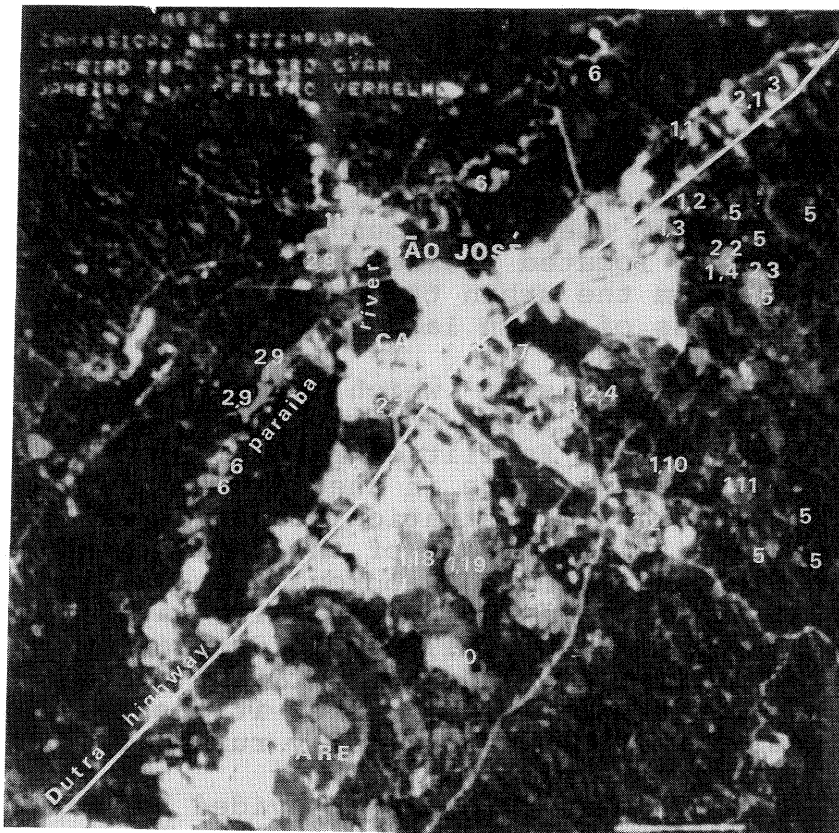


Figure 1 - Urban growth of São José dos Campos obtained from Image Registration Program.

Legend: residential housing estate
 embankment for housing estate
 industry
 crowding residential areas
 rural cottage
 sand quarries.

Deforestation areas (number 5 in Figure 1) for settling of rural cottage can only be differentiated from suburb housing estates through field checking.

Figure 1 shows that urban areas and sand quarries present the same spectral pattern which results in the red color. These areas can not be spectrally discriminated. So, the location of sand quarries along the river is an important key to their distinction.

By analysing the multivariate color composite (obtained from the merging of image pair) the changes that occurred in the urban

structure from 1978 to 1984 were evaluated.

In 1978 the urban area represented by light gray level in the multidate composite was a continuous tissue located mainly along the Presidente Dutra highway.

In multidate composite the reddish areas identified as housing estate or embankment during the ground truth investigation indicate the urban growth as basically characterized by new areas disconnect from the urban boundary. In the other hand some housing states located within the urban boundary (fringe) appear isolated from the urban tissue charactering a spatially discontinuous process of urban land use.

This fragmentary urban tissue which requires great investments to provide the infrastructure, the settling of social use equipments and the urban facilities results from the process of housing estate taking place in the brazilian cities. This process is related to administration practices which conceives housing estates as isolated units of the urban tissue during both its planning and its legal approval and doesn't deal with the urban structure in a comprehensive way. In addition to that the laws that controlling the definition or urban use areas have made easier the incorporation of rural estates into the urban tissue. This trend makes it possible to create profitable housing estates in typically rural areas.

The neglect of the technical support provided by urban planner to approve new housing estates is another factor which explains the fragmentary growth of the São José dos Campos urban area.

4. CONCLUSION

The technique presented in this paper proved to be suitable to derive spectral and time information on urban growth trends. It also helped during ground truth investigations allowing to identify large areas of urban use change.

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