STUDYING THE CHRONICLE OF TIMBERLAND USING HISTORICAL ORTHOPHOTO AND SATELLITE DATA

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ABSTRACT: Timber inventory is a good starting point for developing strategies to effectively manage the timberland. In the sale of timberland, pricing is mostly based on this inventory. For a small timberland, inventory by conventional ground survey could be possible. In the case of large and nationwide business transactions, swift and inexpensive inventory is worth to be considered as the conventional methods require more experienced man power, money and time. In the present study, it was aimed to identify the chronicle of timberland such as changes that has occurred owing to silvicultural activities and by other means using the historical aerial photography and satellite data. Historical aerial photos from National Aerial Photography Program (NAPP), National High Altitude Photography (NHAP), Survey Photography and Landsat satellite data were used. Orthophotos were constructed using the DOQQ and DEM from USGS. Simple photo interpretation technique was employed to classify the orthophoto and satellite data. The plantation area was classified into softwood, mixed and hardwood. The timber age and the corresponding acreage details and the changes were also estimated. The result of this study could be more useful to the timberland buyers to better understand the chronicle of timberland of their interest prior to transactions.

KEY WORDS: Orthophoto, Timber inventory, Remote sensing, Change detection

1. INTRODUCTION

Timber inventories are important for more than just timber sales. An inventory is a good starting point for developing a management plan to help the managers for effective management. The details of timber resources that an inventory provides is essential in determining the course of action necessary to meet the management goals and to estimate the monetary value of the timber resources (MacLean and Colin, 1981, Trotter et al., 1997). In the sale of timberland, pricing is based on inventory no matter what kind of appraisal method is applied.

Conventional method of timber inventory requires lots of man power and money. Fieldwork by foresters or investors themselves would be a better choice to ensure quick turnaround as well as accurate timber estimates. However, large and nationwide business transactions of more than several thousand hectares, accurate and inexpensive inventory is worth to be considered (Franklin 1986, Ardo 1992, Brockhaus and Khorram 1992, Curram and Hay 1986, Wynne and Randolph 2004). From the perspective of time and cost, in-house historical image analysis is an alternative for conducting such an initial appraisal (Wynne and Randolph 2004). On the contrary, a problem of this analysis is the gap between the present time and the most recent date when aerial photography was taken. Use of satellite images could be a solution to fill the gap. Several authors have reported statistically significant correlations between Landsat TM data and forest field data (Tomppo and Katila 1991, Nemani *et al.*, 1993, and Trotter *et al.*, 1997). Therefore the present study was undertaken to assess a series of historical aerial photograph and Landsat TM data of a timberland for building chronicle and to identify the changes.

2. STUDY AREA

The study area is a watershed situated in the Sabine River between Texas and Louisiana of United States. The timberland present in this watershed covers totally about 4716.21 ha. The geographical coordinates of this area are between 30°37'21'' - 30°46'52''N and 93°32'41" - 93°41'02'' W. The climate of this region includes mild winter, high annual rainfall, and moderate to high humidity. The average annual precipitation reaches up to 1500 mm. Generally, the heaviest rainfall occurs in the late spring, with the mid-summer months being the driest.

3. MATERIALS AND METHODS

Aerial photos for the year 1974, 1978, 1981, 1985, 1989 and 1996 were procured from National Aerial Photography Program (NAPP), National High Altitude Photography (NHAP), and Survey Photography archived by the United States Geological Survey (USGS). In addition, 1meter

Digital Ortho Quad Quadrangle (DOQQ) and 10m Digital Elevation Model (DEM) available for most of the U.S. continent were also used as control points and terrain models for ortho-rectification of the images. Landsat 7 Thematic Mapper (TM) data for the year 2003 was also used.

3.1. Orthorectification Process

There were three input datasets in the process namely historical aerial photography, DOQQ, and DEM. On the whole, the framework of the workflow was the same as that of the present digital photogrammetry. A USGS certified camera calibration report defines the unique geometrical relationship between the lens and film of each camera.

The DOQQ was used for collecting longitude (X) and latitude (Y) values of control points. Road intersections, edge of man-made structures, and any other well-defined points were chosen for GCPs. In addition to X and Y, the altitude values (Z) was obtained from USGS DEMs. GCPs from DOQQs and DEMs and outlier removal techniques could ensure a successful completion in block adjustment. Table 1 summarizes the positional accuracy of the historical orthophotos. Reference data was 1998 DOQQ of 1 m resolution. With respect to about 15 well-defined points, the RMSE (Root Mean Square Error) of each orthophoto was within 3 pixels. Figures 1 and 2 illustrates the orthophotos.

Table 1. Accuracy assessment of the historical orthophotos

Date	Resolution	No. of points	RMSE
1996-1-12 (NAPP)	2m	15	4.0m
1989-11-16/3-10 (NAPP)	2m	15	5.7m
1985-12-15	3m	14	6.1m
1981-12-4 (NHAP)	3m	15	6.9m
1978-10-10	3m	14	7.7m
1974-11-27	5m	15	13.3m

3.2. Interpretation and change detections

Standard visual interpretation technique was applied to a series of orthophotos. The same photo interpretation technique was applied to all the photos from 1974-1998. The results were then aligned from recent to previous. Supervised classification technique was employed to classify the Landsat TM image. Change detection analysis was also performed to identify the changes between the periods.

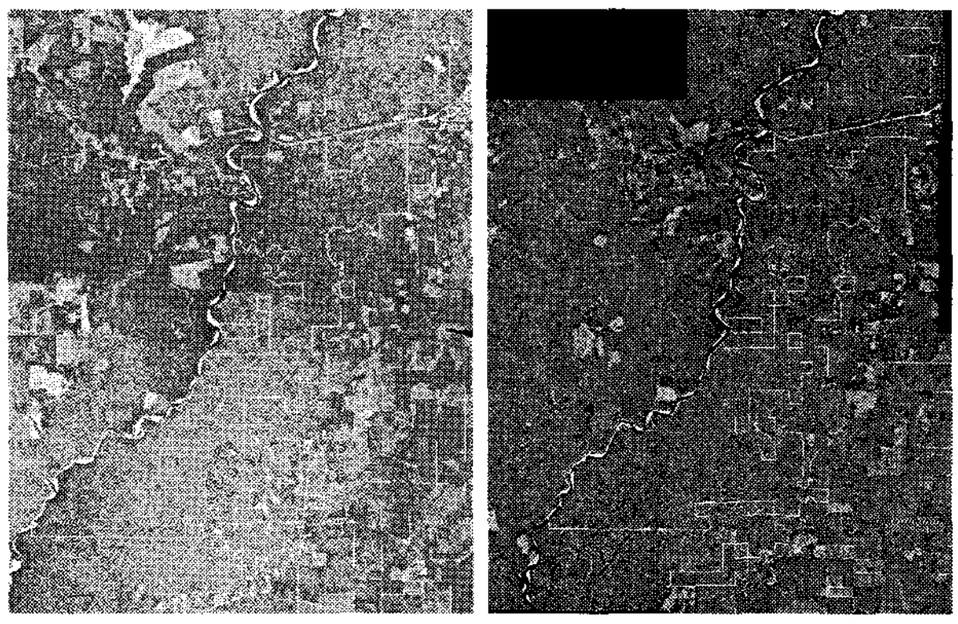

Figure 1. Digital orthophoto of the project area (Yellow line indicates the boundary of the study area).

4. RESULTS AND DISCUSSION

The classification and subsequent change detection portrayed the changes that have occurred in the area. The total area of the timberland was 4716.21 ha. Among them softwood, mixed and hardwood plantations occupied 589.22, 277.62 and 3294.15 ha respectively. There were other classes such as water body, wetland and non-forest area that occupied 99.55, 21.04 and 434.63 ha respectively (Table 2 and Figure 3).

Table 2. Thematic Acreage of the Tract

Class	Area in hectare	Sub categorized area (ha)
Water	99.55	
Wetland	21.04	
Total Softwood	589.22	
Softwood (~5 years)		39.66
Softwood (5~15 years)		275.59
Softwood (15~25 years)		193.84
Softwood (+ 25 years)		80.13
Total Mixed	277.62	
Mixed (5~15 years)		43.71
Mixed (15~25 years)		108.05
Mixed (+ 25 years)		125.86
Total Harwood	3294.15	
Hardwood (5~15 years)		230.27
Hardwood (15~25 years)		269.93
Hardwood (+ 25 years)		2793.95
Non-forest	434.63	
Total	**4716.21**	

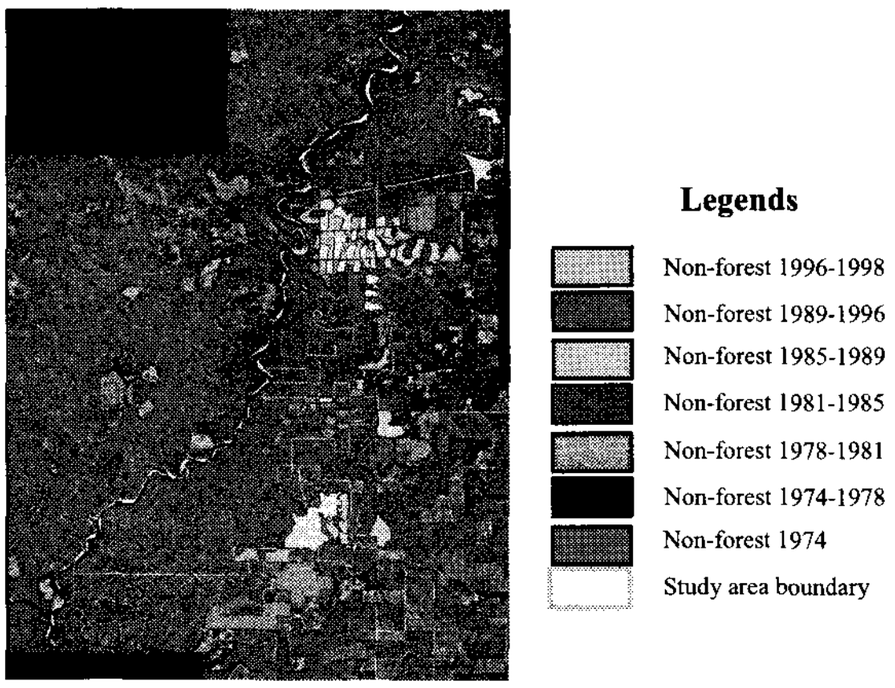

Figure 2. Orthophoto overlaid with change detection details

4.1. Softwood area

In softwood plantation area, about 80.13 ha was unchanged from 1974 to 2003, which was more than 25 years old. About 193.84 ha area was under 15 to 25 years old softwood plantation where the clearing was noticed between 1974 and 1978. About 275.59 ha area was under 5 to 15 years old where clearing was noticed between 1988 and 1998 and about 39.66 ha area was under 5 years old plantation, here the change was noted between 1998 and 2003 (Table 2).

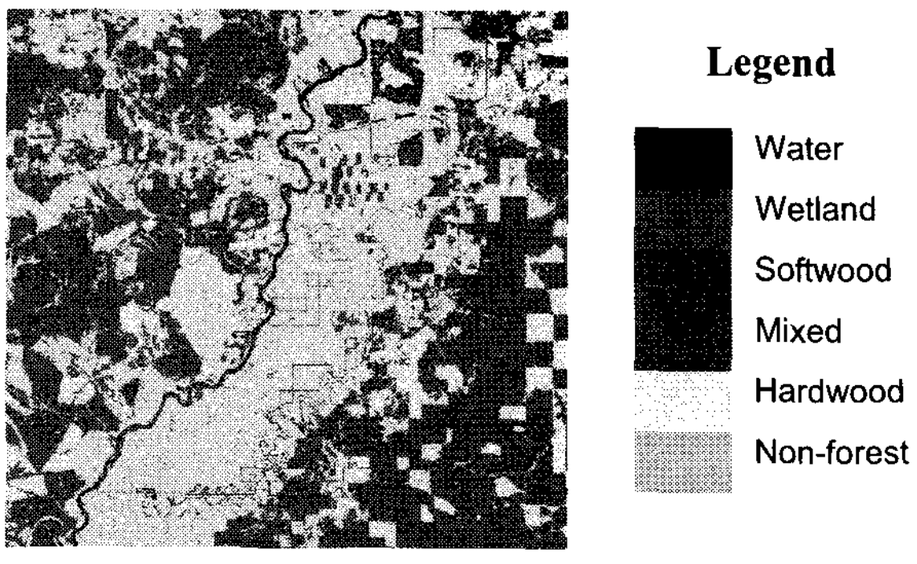

Figure 3. Classified Landsat image

4.2. Mixed wood area

In the case of mixed wood plantation area, about 125.86 ha were found to be more than 25 years old, where no changes were noted. However, about 108.05 and 43.71 ha of mixed wood plantations were under 15 to 25 and 5 to 15 years old respectively. After 1998, there was not any change in this plantation area.

4.3. Hardwood area

Among the three plantation types, the hardwood plantation occupied relatively more area, where 2793.95 ha were found to be more than 25 years old. About 269.93 ha area of this plantation were 15 to 25 years old and about 230.27 ha were 5 to 15 years old (Table 3).

The historical orthophoto analysis in a plantation area revealed that changes have occurred chronologically from 1974 onwards. About 2999.94 ha of plantation area including all the three plantation types showed no changes between 1974 and 2003. Therefore, the timber land in these areas was more than 25 years old. Between 1974 and 1988 about 571.82 ha plantation area of the aforementioned three types were cleared and replanted or regenerated. Therefore, the timber land in these regions was assumed to be 15 to 25 years old. During 1988 and 1998 about 549.57 ha of plantation area have been cleared. Among this, majority of the area belonged to hardwood plantation type. The replanted or regenerated trees of these areas were assumed to be 5 to 15 years old. Only 39.66 ha were found to be cleared between 1998 and 2003, which belonged only to the softwood plantation. On the whole, majority of the timber land area was found to be unchanged between 1974 and 2003.

5. CONCLUSION

In the present study the analysis of historical orthophoto for the forest industries was found to be more useful and informative. Analysis of historical aerial images and satellite image can produce a preliminary inventory of timberland. Though this approach did not provide complete inventory details, it could be used as a ready reference for validating any given inventory. The aerial images and ancillary data archived at the USGS could be used to get information about area of interest within a short period of time. The images from the past very clearly portrayed the changes that occurred in the timberland, any possible defects or natural damage such as wild fire and insect infestation, etc. It could be analogous to reviewing credit report of an individual before any significant business transactions. Timber or timberland buyers now have ways and means to check the chronicle of timberland before their investment.

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