TIMBER AGE ESTIMATION OF COMMERCIAL TIMBERLAND IN TENNESSEE, USA USING REMOTELY SENSED DATA

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ABSTRACT: In the commercially managed timber lands, the information such as height, age, stand density, canopy closure and leaf area index need to be collected periodically. Stand volume is the most fundamental information in the valuation of timber, however, stand age information is the primary element of forest inventory and these two are highly correlated. Conventional method of collecting stand age information by field surveys such as ring count method is accurate; however, it is expensive, labor-intensive and time consuming. In the present study it was aimed to collect stand age information using modern techniques in a commercially managed timberland situated in Tennessee, USA. The Landsat Thematic Mapper (TM), Enhanced Thematic Mapper (ETM+) of three different periods, Shuttle Radar Topography Mission (SRTM), National elevation dataset (NED) and field inventory data were used. Normalized difference vegetation index (NDVI) and Tasselled Cap (TC) transformation techniques were applied on the TM and ETM+ data. The regression analysis was carried out to identify the correlation between stand age and NDVI, TC. In the present study about 2,469 datasets were analyzed. The R^2 value for stand age estimation was 0.713. The NDVI, TC2 and TC3 were found to produce accurate timber age information.

KEY WORDS: Timber age, SRTM, Landsat TM, NDVI, TC, Regression

1. INTRODUCTION

Generally, stand age information is collected by field survey for getting accurate information. However, field survey is expensive, labor intensive and time consuming. This study presents a method of timber age estimation and correlation of timber age using Landsat TM image. Study site is Tennessee in USA for timber age estimation. This study used Landsat TM image, Shuttle Radar Topography Mission (SRTM), Normalized Difference Vegetation Index (NDVI), and Tasselled Cap (TC) transformation image. In this study, Landsat TM images of three different periods (1994, 1994, 1998) were used. Normalized Difference Vegetation Index (NDVI) was prepared from Landsat TM image. Greenness and wetness images were prepared by Tasselled cap transformation. Finally, correlation analysis between timber age and NDVI, TC2, TC3, SRTM was done using regression model.

2. PROCEDURE AND STUDY SITE

2.1 Procedure

The Normalized Difference Vegetation Index (NDVI) and Tasselled Cap (TC) transformation image were derived from Landsat TM images. Ground inventory data was compared with generated image. Regression model was developed. For the application of regression model, we set up a variable. Normalized Difference Vegetation Index (NDVI), Tasselled Cap (TC) transformation and SRTM image are independent variable. Timber age information is dependent variable. Checking the calculated R^2 value, Normalized Difference Vegetation Index (NDVI), Tasselled Cap (TC) transformation and SRTM value were found to produce accurate timber age estimation. Fig. 1 shows the study procedure.

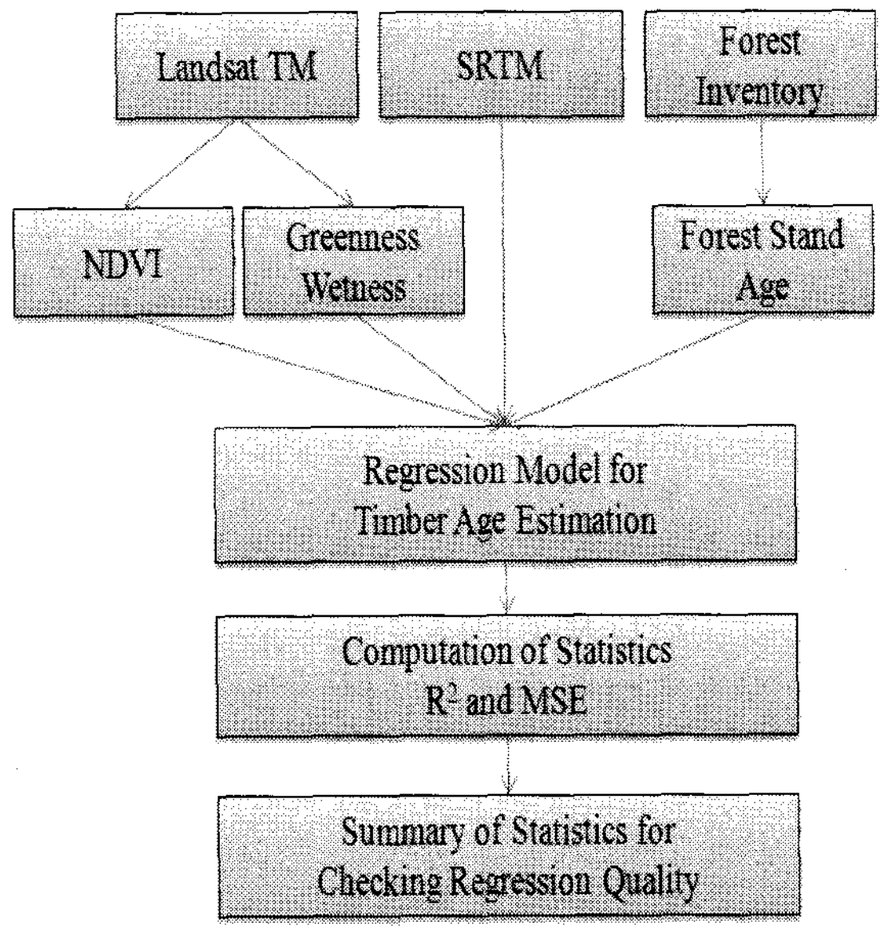


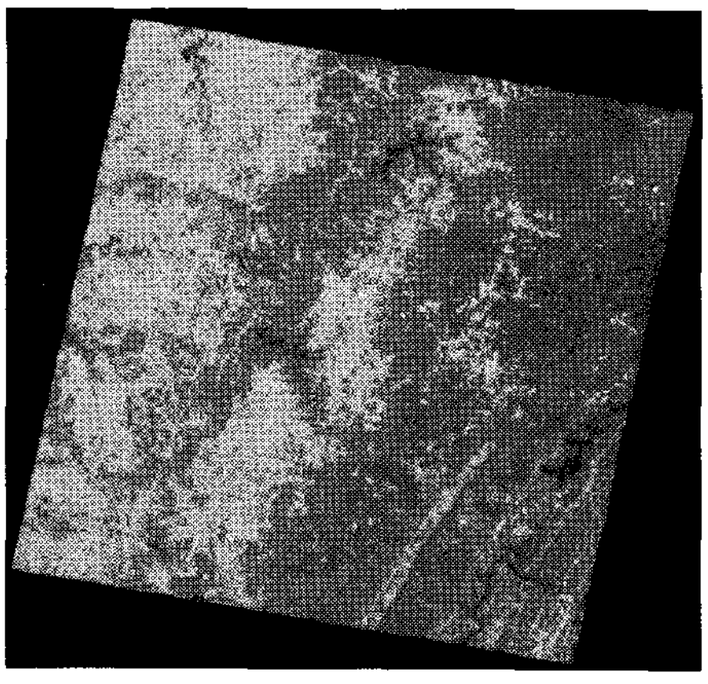
Fig. 1. Flow diagram of present study

2.2 Study Site

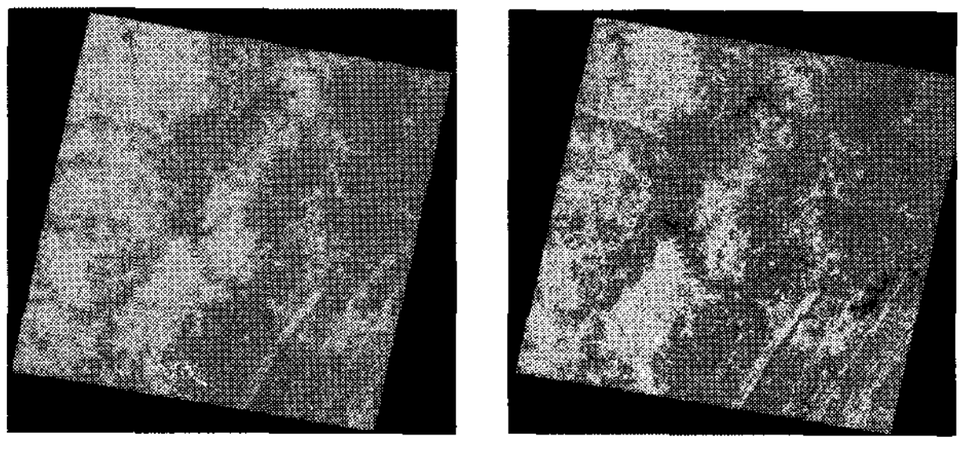
The study site is Tennessee, USA, and used three different period images (1990, 1994, 1998). Table 1 and Fig. 2 show the Landsat TM image and image information.

Table 1. Satellite image information

Sensor	Date	Projection	Coordinate
Landsat TM	1990-09-16	UTM, Zone 16/WGS84	Upper Left (521721, 4097416.5) Lower Right (744705, 3884720.1)
Landsat TM	1994-09-11	UTM, Zone 16/WGS84	Upper Left (521721, 4097416.5) Lower Right (744705, 3884720.1)
Landsat TM	1998-10-24	UTM, Zone 16/WGS84	Upper Left (521721, 4097416.5) Lower Right (744705, 3884720.1)



1990-09-16



1994-09-11 1998-10-24

Fig. 2. Study Site

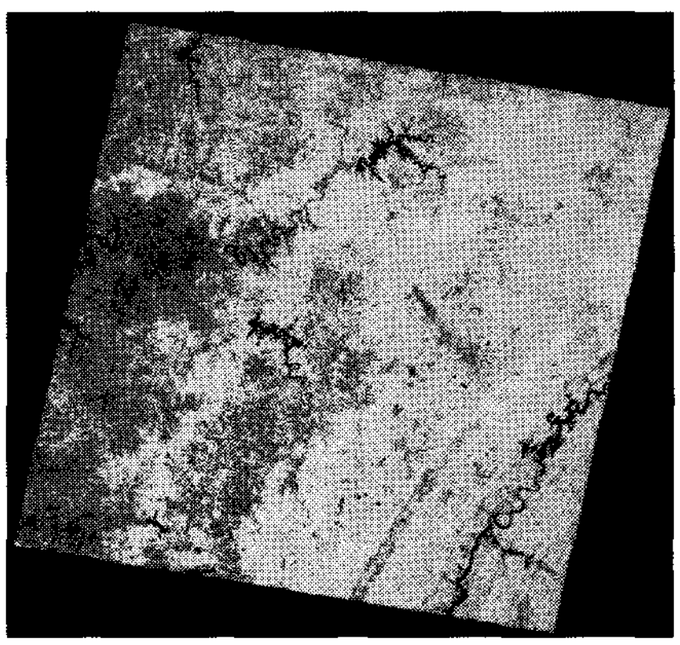
3. METHODS

3.1 NDVI

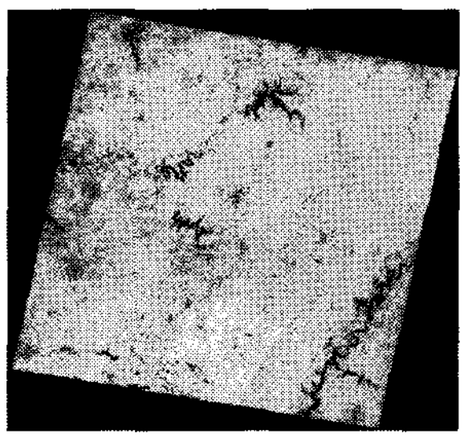
Generally, seasonal and inter-annual changes in vegetation growth and activity can be monitored using Normalized Difference Vegetation Index (NDVI) (Jensen, 2005). Equation 1 shows that the Normalized Difference Vegetation Index (NDVI) (Rouse et al., 1974).

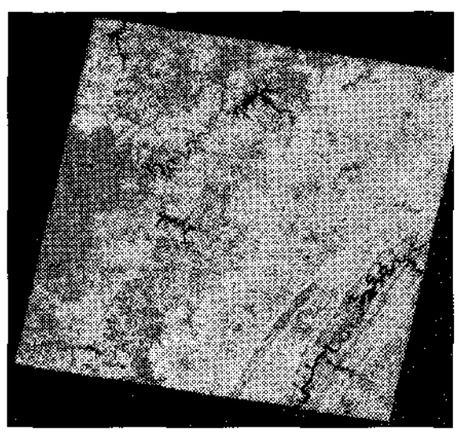
$$NDVI=(\rho_{nir} - \rho_{red}) / (\rho_{nir} + \rho_{red}) \quad (1)$$

Fig. 3 shows NDVI image using equation 1.



NDVI_1990





NDVI_1994 NDVI_1998

Fig. 3. NDVI

3.2 Tasselled Cap Transformation

In this study, Tasselled Cap (TC) coefficients (Equation 2, 3, 4) was used. Generally, urbanized areas are particularly evident in the brightness image. The greater the biomass, the brighter the pixel value in greenness image. The wetness image provides subtle information concerning the moisture status of the wetland environment. As expected, the greater the moisture content, the brighter the response (Crist and Kauth, 1986).

$$B=0.2909TM1+0.2493TM2+0.4806TM3+ 0.5568TM4+0.4438TM5+0.1706TM7 \quad (2)$$

G=-0.2728TM1-0.2174TM2-0.5508TM3+
0.7221TM4+0.0733TM5-0.1648TM7 (3)

W=0.1446TM1+0.1761TM2+0.3322TM3+
0.3396TM4-0.6210TM5-0.4186TM7 (4)

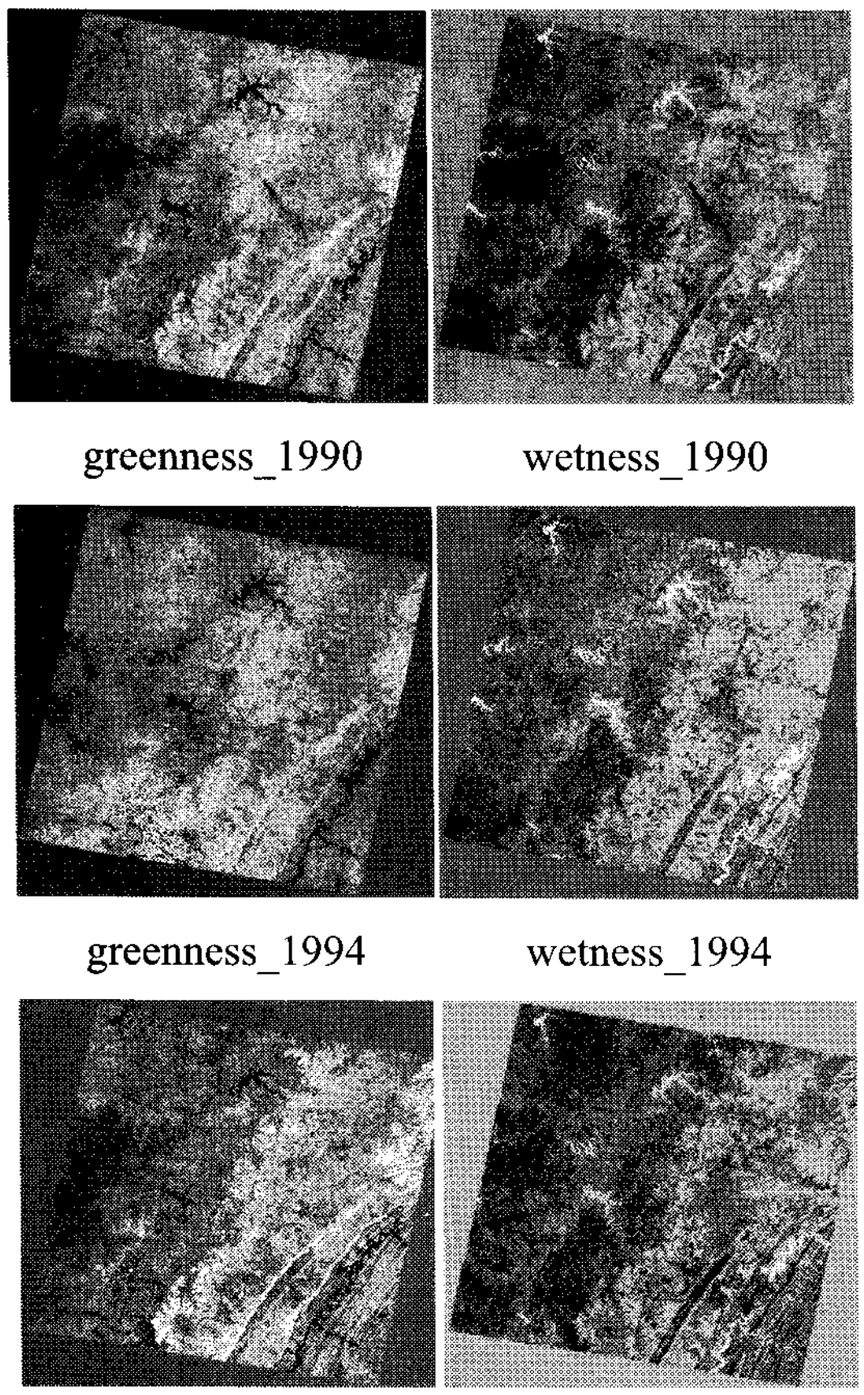


Fig. 4. Tennessee Tasseled Cap Image

3.3 Regression Model

The plantation year has range from 1953 to 2001. Entire observation number is 2,496. Table 2 shows result of regression analysis.

Table 2. Result of regression analysis

	Value
Observation Number	2,469
R^2	0.7131
RMSE	4.7921

4. CONCLUSION

This study presents a method for estimation of timber age. This study result proved that Normalized Difference Vegetation Index (NDVI), Tasselled Cap (TC) transformation and SRTM images are related to timber age estimation. Result of regression shows 0.7131 R^2 value. However, this study needs more data analysis, for example, removing outlier and application of tree regression. When additional studies are performed, the R^2 value would be improved.

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