

Deforestation of Tropical Rainforests Near Palembang, Indonesia

Joshua Schoen

Faculty Sponsor: Cynthia Berlin, Department of Geography and Earth Science

ABSTRACT

Deforestation is a major concern for the western Indonesian island of Sumatra. It has faced heavy deforestation in the past and only thirty percent of its original tropical rainforest still exists today. As a result, many species have been driven to extinction. The purpose of this research was to assess deforestation of a study area north of the city of Palembang on Sumatra. To accomplish this, two different satellite images were used: a Landsat TM image from 1992 and a Landsat ETM image from 2001. An unsupervised classification was performed to cluster pixels based on their spectral signatures. This makes it possible to distinguish areas that have undergone deforestation as well as areas that are in a period of secondary succession after being deforested. By comparing the results of the two image classifications, the amount of deforestation for the nine-year period was determined. Dense forests decreased by 48%, and low density forests decreased by 24%.

INTRODUCTION

Indonesia possesses one of the largest areas of tropical rainforest in the world, representing 10 percent of the world's remaining tropical rainforest (Arunarwati *et al.*, 1997). Indonesia's tropical rainforests support very high biodiversity and are considered among the richest ecosystems in the world. Moreover, 16 percent of the entire world's bird species, 11 percent of its plant species, and 10 percent of all mammals are found in Indonesian tropical rainforests (NASA, n.d.). Among the unique species found in this region are the endangered species Orangutan and Sumatran Tiger.

Deforestation of Indonesian tropical rainforests is of major local and global concern. Indonesia is rapidly losing its tropical rainforests at a rate of approximately 5 million acres a year. Furthermore, the Indonesian island of Sumatra only has 30 percent of its original tropical rainforests and at its current rate of deforestation, Sumatra could be completely deforested by the end of the year 2005 (NASA, n.d.).

Deforestation is commonly defined as the rate of change of forested cover area caused by changing the use of forested land from forest to non-forest cover. In Sumatra, several factors are responsible for tropical rainforest deforestation. They include conversion to arable agricultural land, commercial and illegal logging, human migration, and forest fires (Djoeachir *et al.*, 2004).

Remote sensing can serve as a valuable tool for the detection of deforestation. Through image processing techniques, satellite images that are taken over a given time interval can indicate the spatial extent and amount of deforestation for a specific location. Landsat Thematic Mapper (TM) and Enhanced TM (ETM) satellites both serve as important sources of imagery and are characterized by having a 30-meter spatial resolution.

STUDY AREA

The study area is located on the Indonesian island of Sumatra, north of the city of Palembang and in a lowland that contains the outlets of the Musi, Pulau Rimau and Banyanasin Rivers into the Bangka Strait. Of the 2470-acre study site, approximately 285 acres are water surfaces. The study site is subject to environmental degradation due to uncontrolled logging, the rapid conversion to agricultural land, and the development of shrimp and fish ponds. Most of the land converted to agriculture yields rice during the rainy season and a secondary crop such as corn, soybeans, chilies, watermelon or string beans during the dry season (Djoeachir *et al.*, 2004).

DATA SOURCES AND METHODS

Landsat TM data acquired on June 26, 1992 and Landsat ETM data acquired on July 13, 2001 provided the spectral data used in the computer classification. The image processing was performed using ERDAS Imagine 8.6.

Once the images were imported into Imagine, they were referenced to one another through the use of twelve ground control points. Since the original images were larger than needed for this research and there was cloud cover in parts of the images, a subset site was selected (Figures 1 and 2).

The analysis method used a standard unsupervised ISODATA classification approach using the six reflective bands. The classification created 25 signature classes, which were analyzed and recoded into the six land cover classes used in this research. The six land cover classes are water, dense natural forest, low density forest, agriculture/secondary growth, unhealthy vegetation, and soil.

Further assessment of the land cover change over time was possible through the use of a matrix function. The matrix function created a thematic file that shows how the two classifications used in this research overlap. In addition, a summary function was used to provide comparative statistics for the two images.

RESULTS AND DISCUSSION

The 25 spectral classes produced by the unsupervised classification were grouped into six land cover classes according to their spectral signatures. Band 1 was neglected in the spectral interpretation since it contained a high amount of atmospheric scattering. The spectral signature of water differentiated itself from the other classes because of its lower response in the NIR and MIR bands. Likewise, the soil land class also differentiated itself from the other land classes by having a relatively high spectral response in all the reflective bands. The dense natural forest separated itself from the low density forest by having a higher response in the NIR band and by displaying a more ideal green peak/red depression pattern due to its chlorophyll and moisture content. The agriculture and secondary growth land class ideally would have been divided into two classes. However, without any verified ground truth data for the study site they had to be grouped together, despite most of the pixels in the class occupying agricultural land.



Figure 1. June 26, 1992 Landsat TM Image.

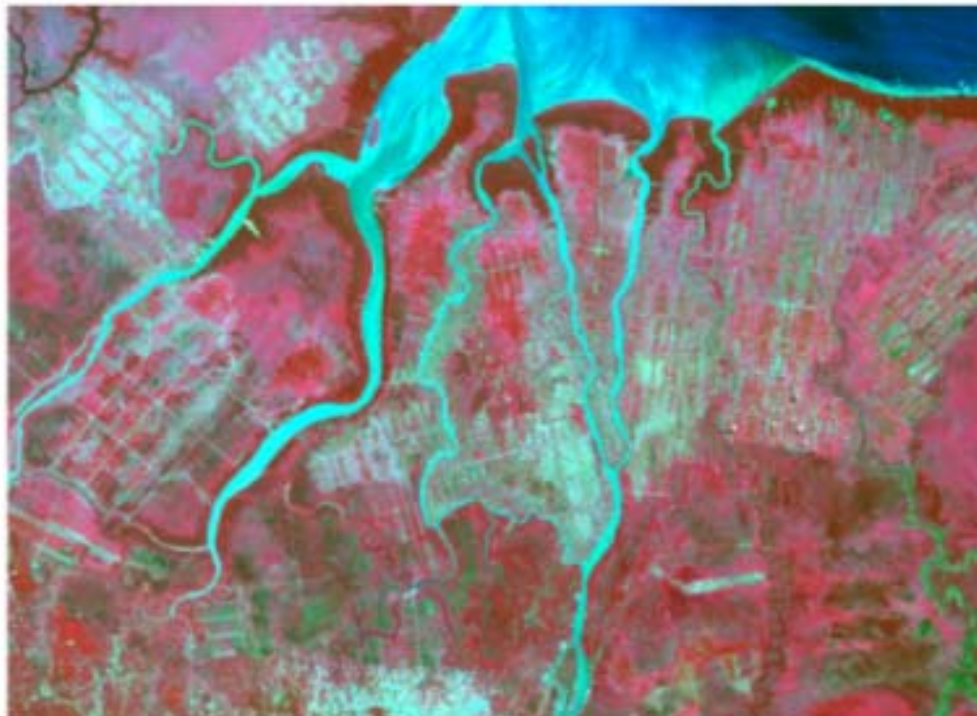


Figure 2. July 13, 2001 Landsat ETM Image.

Agriculture/secondary growth spectrally separated itself from other vegetation forms by having higher NIR and MIR responses, as well as having a relatively high green/red ratio. The unhealthy vegetation class displays a spectral response of poor green/red ratio and relatively lower NIR and MIR responses, depicting very unhealthy forest/vegetation.

Results of the classification showed a reduction in the forested areas of the study site. As shown in Table 1, there was a significant reduction in both the dense natural forest and the low density forest classes. The dense natural forest had the greatest reduction at 48.1 percent. Low density forests were reduced by 24.2 percent. The loss of dense natural forest near rivers, especially the converging outlets of the Pulau Rimau and Banyanasin Rivers, is very noticeable by analyzing Figure 3 a (1992 classification) and b (2001 classification). In addition, a reduction of dense natural forest also occurred in the northwest corner of the study area.

Table 1. Land Cover Change from 1992 to 2001.

LAND COVER	1992 IMAGE (ACRES)	2001 IMAGE (ACRES)
Water	289.1	282.3
Dense Natural Forest	672.3	349
Low Density Forest	218.3	165.5
Secondary Growth/Ag	912.7	1255
Unhealthy/Secondary	204.9	133.5
Soil	173.2	284.8

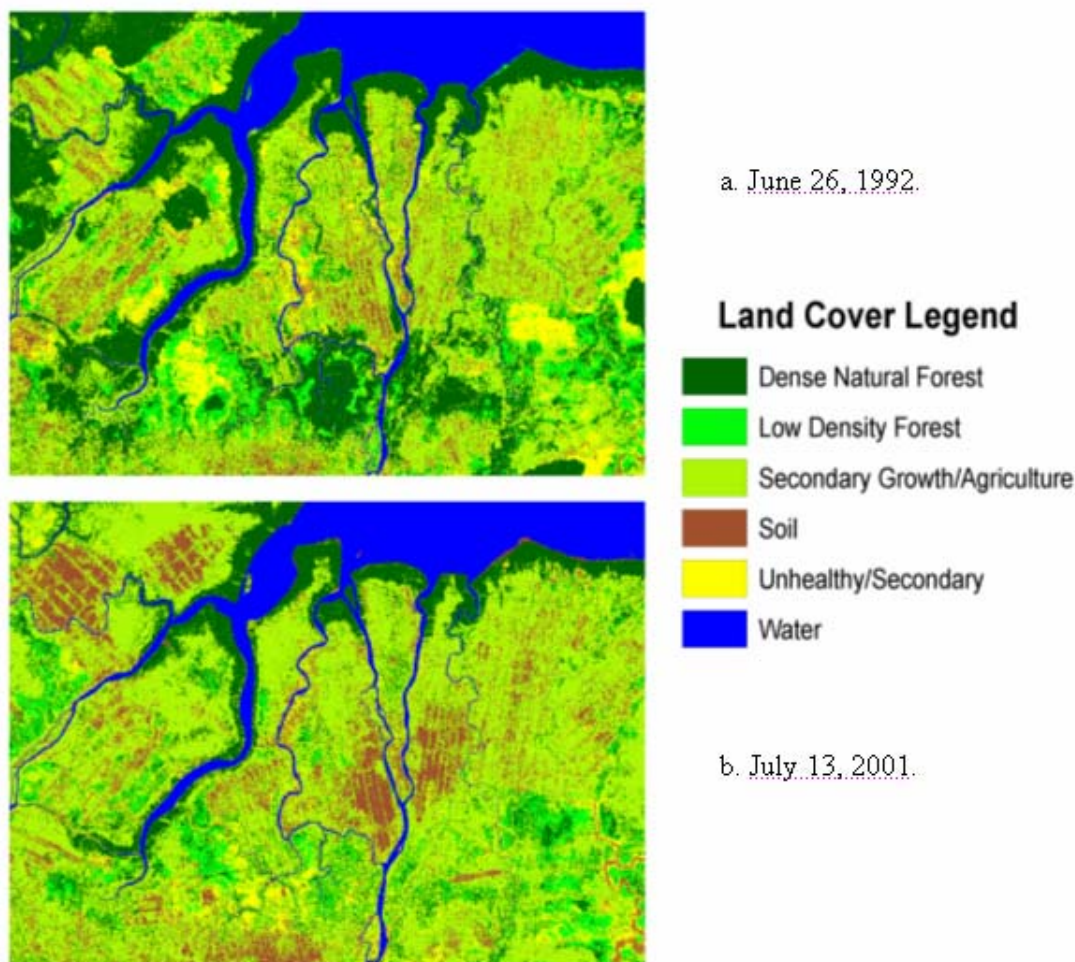


Figure 3. Land Cover Classification Results.

While there was a reduction in the amount of forested land, there was an increase in area for the land classes secondary growth/agriculture and soil. Secondary growth/agriculture (mostly agriculture) had the greatest increase in acreage, but soil had the larger percentage increase. The secondary growth/agriculture land class had an increase of 37.5 percent. The soil class, which is primarily agricultural land, increased by 64.4 percent.

Through the use of a summary function on the classified images, it was determined that the majority of the area classified as dense natural forest and low density forest in 1992 was classified as secondary growth/agriculture in 2001 (Tables 2 and 3). Forty-six percent of the area classified as dense natural forest in the 1992 image was later classified as secondary growth/agriculture in the 2001 image. Moreover, 43 percent of the area classified as low density forest in 1992 was later classified as secondary growth/agriculture in 2001. In both classes, more of the pixels classified as dense natural forest and low density forest in the 1992 image were classified as secondary growth/agriculture in 2001 than classified in their previous respective land cover classes for that date. This suggests that a majority of the area classified as dense natural forest or low density forest in the 1992 image had been forested between the dates of the two images and is now being used for agricultural purposes or undergoing secondary succession.

Table 2. Dense Natural Forest Summary Statistics.

CHANGE FROM 1992 TO 2001		
LAND COVER CLASS	PIXELS	%
Water	7655	0.28
Dense Natural Forest	948202	34.85
Low Density Forest	259039	9.52
Secondary Growth	1251518	46.00
Unhealthy/Secondary	130925	4.81
Soil	123244	4.53

Table 3. Low Density Forest Summary Statistics.

CHANGE FROM 1992 TO 2001		
LAND COVER CLASS	PIXELS	%
Water	4120	0.47
Dense Natural Forest	103576	11.72
Low Density Forest	155238	17.57
Secondary Growth	3800442	43.06
Unhealthy/Secondary	148781	16.84
Soil	91279	10.33

CONCLUSION

The main objective of this research project, to determine the spatial extent and amount of deforestation for the selected subset image over a nine-year period, was successfully achieved. The research indicated a loss of 376.1 acres of dense natural forest and low density forest for the 2087.8 acre non-water portion of the study area between the dates of June 26, 1992 and July 13, 2001. The loss reduces the overall amount of dense natural forest and low density forest to 57.7 percent of the area classified for those respective classes nine years earlier. In addition, an inverse relationship between the rate of deforestation and an increase in the area classified as secondary growth/agriculture was observed. The inverse relationship was characterized by a 342.3 acre increase for the secondary growth/agriculture land class while there was a 376.1 acre loss in dense natural forest and low density forest.

REFERENCES

- Arunarwanti, B., Hussin, Y.A., and Weir, M. 1997. Detecting Tropical Deforestation Using Satallite Radar Data: A Case Study From Central Sumatra, Indonesia. URL: <http://www.gisdevelopment.net/aars/acrs/1997/ts5/ts5002pf.htm> (23 April 2004).
- N.A.S.A., n.d. Deforestation in Sumatra, URL: http://earthobservatory.nasa.gov/Newsroom/NewImages/images.php3?img_id=9277 (28 April 2004).
- Djoeachir, M., Houterman, J., Susanto, R.H., and van Steenberg F., 2004. Water Resources Management During Transitional Reform in Indonesia: Toward an Integrated Perspective on Agricultural Drainage, February 2004, URL: [http://inweb.worldbank.org/ESSD/ardext.nsf/11ByDocName/WaterResourcesManagementduringTransiti onandReforminIndonesiaTowardanIntegratedPerspectiveonAgriculturalDrainageSection4-6/\\$FILE/ID_section_4-6.pdf](http://inweb.worldbank.org/ESSD/ardext.nsf/11ByDocName/WaterResourcesManagementduringTransiti onandReforminIndonesiaTowardanIntegratedPerspectiveonAgriculturalDrainageSection4-6/$FILE/ID_section_4-6.pdf) (26 April 2004).