ANALYSIS OF FOREST CHANGE IN FIRE DAMAGE AREA USING SATELLITE IMAGES

Joon Mook Kang, Professor
Joon Kyu Park, Ph.D
Min Gyu Kim, Ph.D._Candidate
Dept of Civil Engineering, Chungnam National University
220 Gung-dong, Yuseong-gu, Daejeon, 305-764, Korea
jmkang@cnu.ac.kr
surveyp@empal.com
kmgtpq@paran.com

ABSTRACT

Although disaster prevention measures are very important, accurate investigation of damages and effective restoration are also crucial for understanding and dealing with forest fires. Collection of accurate information about forest fire damage is a difficult task because it usually occurs in far field mountainous regions and involves wide areas making field survey a very challenging task. Remote sensing by satellite image is used to get consecutive information about the range and ecological change of the damaged area. And NDVI (Normalized Difference Vegetation Index) can be calculated from reflection value of the image in order to analyze status of the vegetation. This study focuses on the efficiency of NDVI through comparative analysis of pre- and post-fire images.

INTRODUCTION

Forest fire is one of the main factors disturbing the environment of forest, and it influences greatly the constitution and function of forest according to the fire damage. It is required a lot of man powers and budgets to calculate fire damage degree and process of vegetation rehabilitation at the damaged area after large-fire. However, the analysis of forest fire damage using satellite image can acquire rapidly information and more objective results remotely in the large-fire area. In this study, Landsat satellite images have been used to calculate fire damage area. Pre- and post-fire images from the Landsat TM and ETM+ to calculate the evaluate large-scale patterns of fire damage for analyzing forest fire damage of Cheong-yang and Ye-san fire in 2002, and the NDVI has been used for monitoring the state of the revegetation. Figure 1 shows the flow chart of this study.

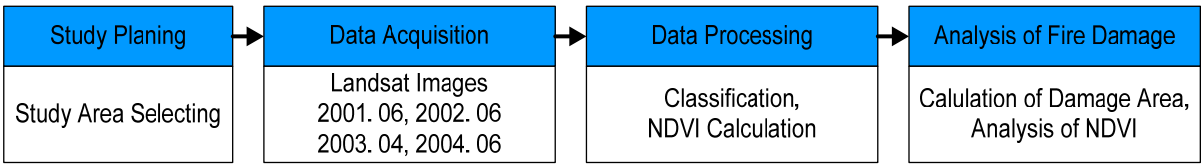

Figure 1. Study Flow Chart.

DATA ACQUISITION AND PROCESSING

In this study, Chung-yang and Ye-san were selected for the study site. These sites were occurred forest fire on a large scale in 2002. The damaged area by forest fire was calculated using Landsat images which were four years from February in 2001 to June in 2004 and the vegetation recovery was monitored. Figure 2 shows satellite image about the study site (boxed area).

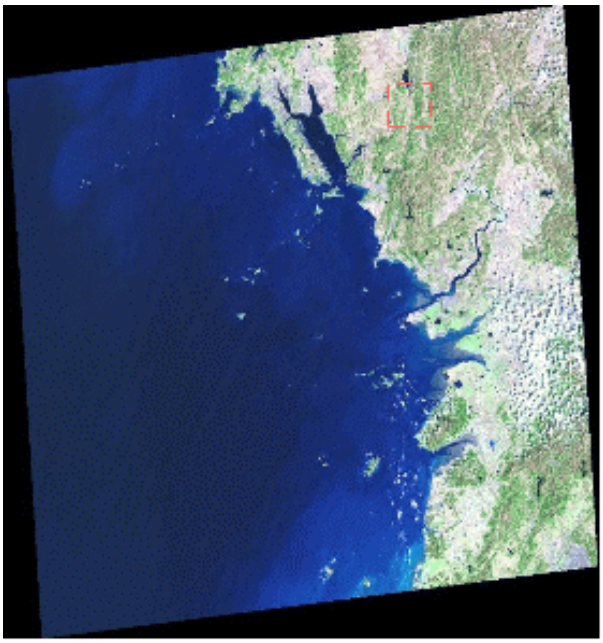

Figure 2. Satellite image about the study site.

Table 1 shows the list of Landsat image and Figure 3 shows Landsat imageries for the four years used in this study.

Table 1. List of Landsat Images

	Satellite Images			
Sensor	Landsat ETM+	Landsat ETM+	Landsat ETM+	Landsat TM
Date	2001. 06	2002. 06	2003. 04	2004. 06
Spec.	30m	30m	30m	30m
	Multi-Spectral	Multi-Spectral	Multi-Spectral	Multi-Spectral

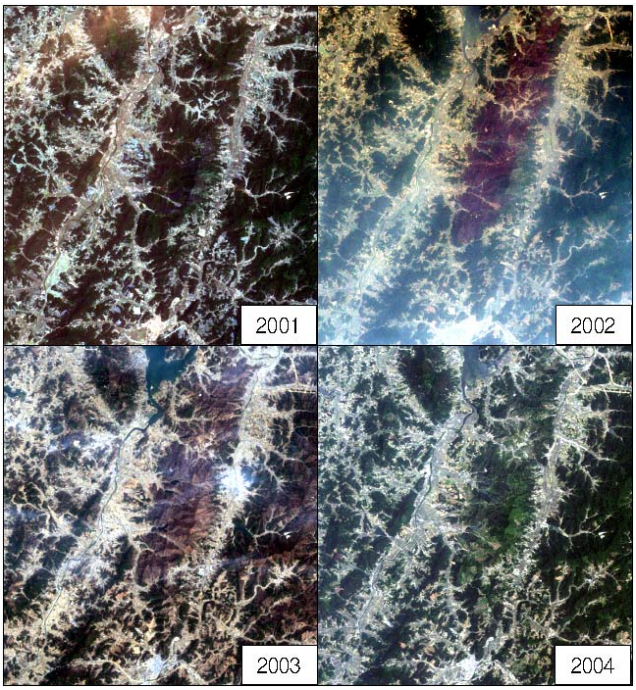

Figure 3. Landsat images.

Classification

In this study, the supervised classification method was used to classify the image. False-color composition using 4band, 3band and 2band of Landsat image was carried out to classify the pre- and post-fire images precisely. It is usually used for vegetation classification. In the color composite image, the healthy vegetation reflects or radiates the infrared light strongly and it seems to be red in the false-color image. In order to classification of image, training set was set by sorting the identifiable land cover into water system, vegetation, damage area of forest fire, etc. It was classified by the Maximum likelihood algorithm. Figure 4 shows the training set for supervised classification and Figure 5 shows the results of classification.

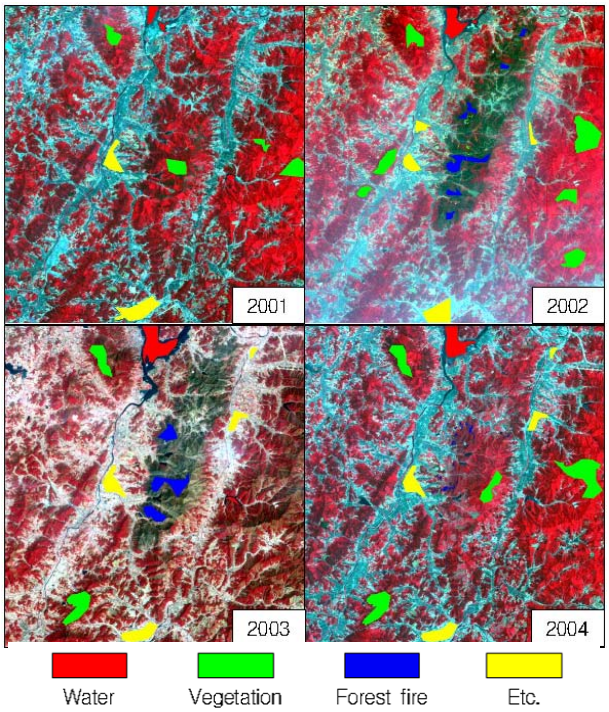

Figure 4. Class and Training Set.

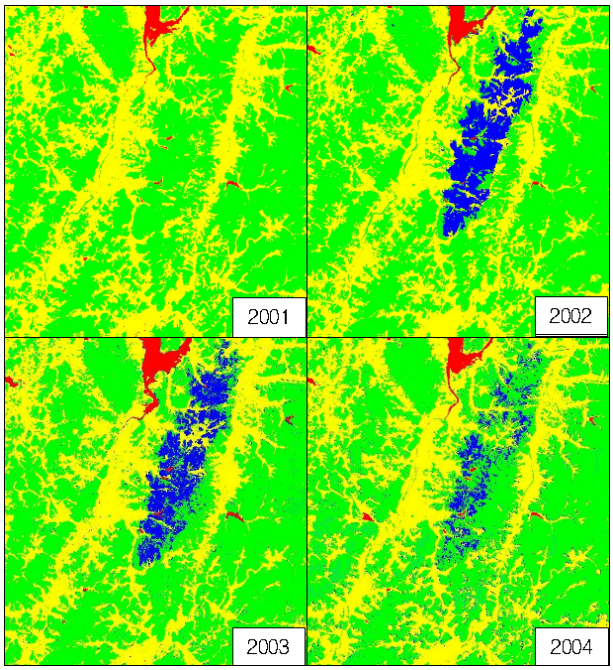

Figure 5. Results of Classification.

The classified results compared the classified image about appointed class with original image were satisfactory. The area sorted into etc. contained vegetation, lake, bare soil. Forest, damage area, bare soil in the study area were classified precisely.

NDVI

NDVI is defined as the difference and ratio of reflection between visible ray and near infrared wavelength. In this study, it was used to detect the change of vitality with spatial distribution of vegetation. Figure 6 shows the computation results of NDVI. The dark part expresses the area where is no or low vegetation and the bright part expressed the area where is high vegetation vitality.

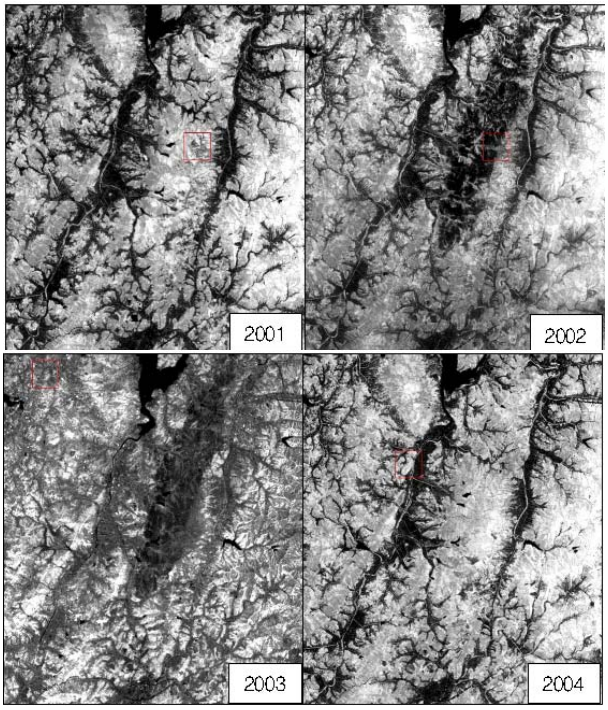

Figure 6. The computation results of NDVI.

RESULT AND ANALYSIS

In this study, vegetation classification for the four years (2001, 2002, 2003 and 2004) image was carried out. The number of pixels in each class about the classified image was calculated and the area in each class was computed using the area of one pixel (900m^2). Table 2 shows the classification result of image and Figure 7 shows the graph of classification result in the year 2001.

Table 2. The classification result of image in the year 2001

Class	Classification result 2001		
	Number of Pixel	Area (km^2)	Ratio (%)
Water	3,643	3.28	1.02
Etc.	143,150	128.84	40.03
Vegetation	210,783	189.70	58.95
Forest Fire	0	0	0

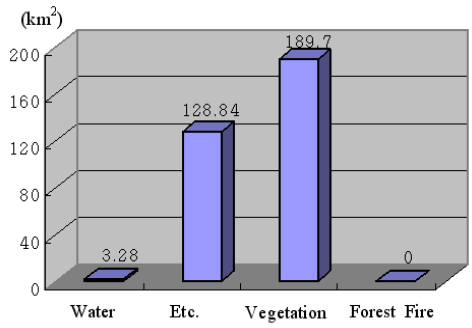

Figure 7. The graph of classification result in the year 2001.

The classification result of image in June 2001 when is before the forest fire shows that vegetation is 58.95%, etc. containing bare soil, roads, agriculture lot is 40.03%, water system is 1.02%. Table 3 shows the classification result of image and Figure 8 shows the graph of classification result in the year 2002.

Table 3. The classification result of image in the year 2002

Class	Classification result 2002		
	Number of Pixel	Area (km^2)	Ratio (%)
Water	3,523	3.17	0.99
Etc.	132,876	119.59	37.16
Vegetation	198,424	178.58	55.49
Forest Fire	22,753	20.48	6.36

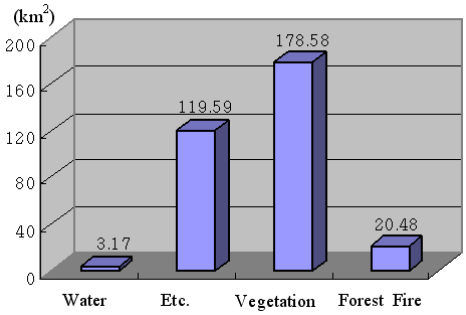

Figure 8. The graph of classification result in the year 2002.

The classification result of image in June 2002 when is 2 months later after the forest fire shows that vegetation is 55.49%, etc. containing bare soil, roads, agriculture lot is 37.16%, water system is 0.99%, area of the forest fire damage is 6.36%. The area of the forest fire damage was calculated at 20.48km². Table 4 shows the classification result of image and Figure 9 shows the graph of classification result in the year 2003.

Table 4. The classification result of image in the year 2003

Class	Classification result 2003		
	Number of Pixel	Area (km^2)	Ratio (%)
Water	6,015	5.41	1.68
Etc.	124,333	111.90	34.71
Vegetation	205,721	185.15	57.43
Forest Fire	22,141	19.93	6.18

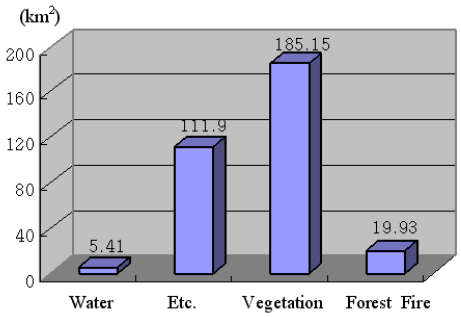

Figure 9. The graph of classification result in the year 2003.

The classification result of image in April 2003 when is 12 months later after the forest fire shows that vegetation is 57.43%, etc. containing bare soil, roads, agriculture lot is 34.71%, water system is 1.68%, area of the forest fire damage is 6.18%. It was figured out that the area rate of the forest fire damage decreased slightly by vegetation recovery in a small part of the forest fire area. Table 5 shows the classification result of image and Figure 10 shows the graph of classification result in the year 2004.

Table 5. The classification result of image in the year 2004

Class	Classification result 2003		
	Number of Pixel	Area (km^2)	Ratio (%)
Water	3,364	3.03	0.94
Etc.	117,644	105.88	32.84
Vegetation	230,633	207.57	64.38
Forest Fire	6,569	5.91	1.83

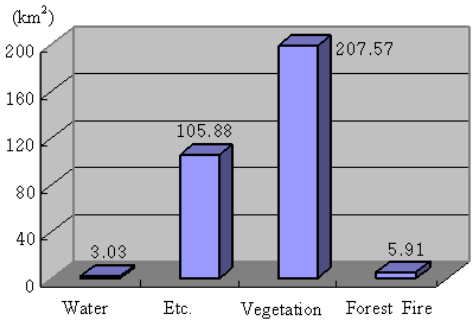

Figure 10. The graph of classification result in the year 2003.

The classification result of image in June 2004 when is 26 months later after the forest fire shows that vegetation is 64.38%, etc. containing bare soil, roads, agriculture lot is 32.84%, water system is 0.94%, area of the forest fire damage is 1.83%. It was figured out that the vegetation of the damage area was recovered about 14km². Figure 11 shows the change of the area about each class.

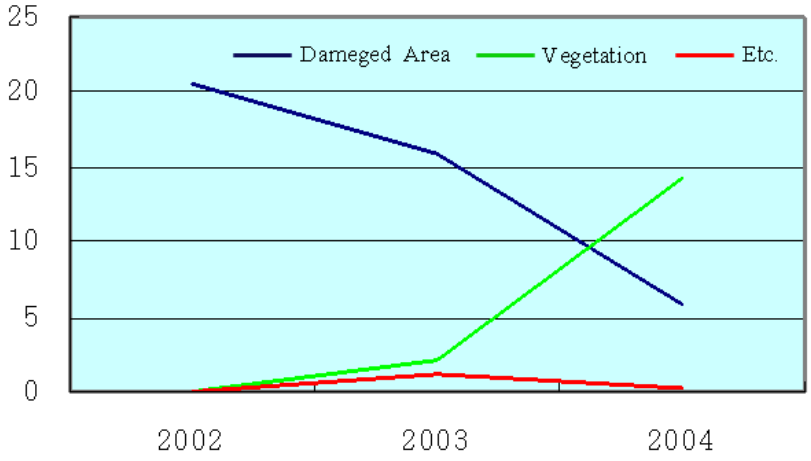

Figure 11. The change of the area about each class.

As a result, area of the forest fire decreased from 20.48km^2 to 5.91km^2. On the other hand, area of the vegetation increased by 14.24km^2. It means the natural recovery of vegetation with time, especially it was figured out that the amount of recovery increased significantly from 2003 to 2004.

CONCLUSIONS

In this study, the followings are conclusions by analysis of forest fire damage and the present situation of vegetation recovery about the area of forest fire using multi-temporal satellite images.

First, state of damage, change of land-cover, damage dimensions about the area of forest fire were capable of calculating effectively using the result of supervised classification about Landsat satellite image.

Second, it could be possible to figure out the degree of vegetation recovery by calculating the NDVI using multi-temporal satellite images that contained pre- and post- fire.

Third, it is expected that the information that is able to be acquired by various satellite data and digital forest type map will be used to monitor the condition of vegetation recovery and ecological change effectively.

REFERENCES

Cocke, A.E. Fule, P.Z., Crouse, J.E., 2005. Comparison of burn severity assessments using Differenced Normalized Burn Ratio and ground data, *INTERNATIONAL JOURNAL OF WILDLAND FIRE*, 14(2):189-198.

Fung, T. and Ledrew E., 1988. The determination of optimal threshold levels for change detection using various accuracy indices, *Photogrammetric Engineering & Remote Sensing*, 54(10):1449-1454.

Jakubaukas, M.E., Lulla K.P. and Mausef P.W., 1990. Assessment of Vegetation Change in a Fire Altered Forest Landscape. *Photogrammetric Engineering & Remote Sensing*, 56(3):371-377.

Kangyung W. and Jungho I., 2001. Fire Severity Mapping Using a Single Post-Fire Landsat-7 ETM+ Imagery. Journal of the Korean Society of Remote Sensing, 17(1):85-97.

Koutsiast, N. and Karteris M., 1998. Logistic regression modeling of multi-temporal Thematic mapper data for burned area Mapping. *International Journals of remote Sensing*, 19(18):3499-3514.

Koutsiast, N. and Karteris, M., 2000. Burned area mapping using logistic regression modeling of a single post-fire Landsat-5 Thematic Mapper image. *International Journals of remote Sensing*, 21(4):673-687.

Lentile, L.B. Smith, F.W. Shepperd, W.D, 2006. Influence of topography and forest structure on patterns of mixed severity fire in ponderosa pine forests of the South Dakota Black Hills. *INTERNATIONAL JOURNAL OF WILDLAND FIRE*, 15(4):23-27.

Patterson, M.W. and Stephan R.Y., 1998. Mapping Fire-Induced Vegetation Mortality Using Landsat Thematic Mapper Data: A Comparison of Linear Transformation Techniques. *Remote Sensing of Environment*, 65:132-142.

Green, K., Kempka D. and Lackey L., 1994. Using remote sensing to detect and monitor land-cover and land-use change. *Photogrammetric Engineering & Remote Sensing*, 60(3):331-337.

Van Wagtendonk, J.W., 2004. Dr. Biswell's Influence on the Development of Prescribed Burning in California, *General Technical Report PNW*, 11-16.