Analysis for Forest Fire Damage Severity Map in Cheongyang

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ABSTRACT: Space-borne multi-sensor data could provide fire scar and burn severity mapping. This paper will present detail mapping of burnt areas in Cheongyang•Yesan of Korea with ETM+ image.

Burn severity map based on ETM+ image was found to be affected by strong topographic illumination effects in mountainous forest area. Topographic effect is a factor which causes errors in classification of high spatial resolution image like IKONOS image.

Minnaert constants κ in each band of ETM+ image is derived for reduction of mountainous terrain effects. Finally, this paper computes quantitative analysis of forest fire damage by each forest types.

KEY WORDS: Forest Fire, Topographic Correction, Minnaert Constant κ

1. Introduction

Forest fire burnt in Korea occupied of most part mountainous area have some problems like bidirectional shadow effects for analyzing forest fire burnt.

This study has executed correction to reduce bidirectional shadow effects for forest fire burnt and supervised classification for forest fire burnt in each forest stand types based on digital forest stand map.

It is expected to present selection of tree species planted for restoration of forest fire damaged.

2. Study Area and Data

Cheongyang and Yesan Gun forest fire damaged is the study area for this study. To analyze forest fire burnt a Landsat 7 ETM+ image(Figure 1) acquired April 6, 2003 is used and digital map(produced by National Geographic Information Institute) is used as a reference to correct geometric distortion of ETM+ image.

In addition, this data is to analyze topographic effects in mountainous area and converts to DEM data and DTM data. For analyzing forest fire burnt in each forest stand type, digital forest stand map is used. This map is produce by Korea Forest Research Institute.

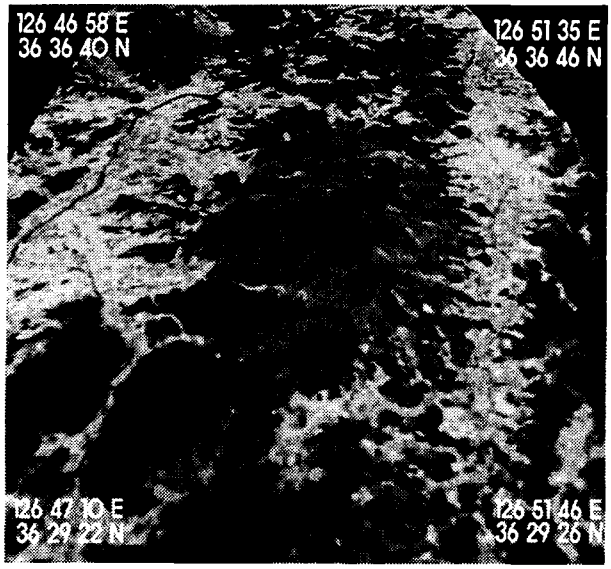

Figure 1. Landsat 7 ETM+ image 3D view of study area in Cheongyang, Yesan Gun(Band 3/2/1)

3. Methodology

Radiometric Correction

Atmospheric effects affect radiance remotely sensed data like ETM+ image. To reduce the errors by atmospheric effects, ETM+ digital numbers (DN) converted to reflectance values by equation (1) and (2).

$$L_\lambda = \frac{LMAX_\lambda - LMIN_\lambda}{QCALMAX - QCALMIN}(QCAL - QCALMIN) + LMIN_\lambda \quad (1)$$

L_λ = Spectral Radiance at the sensorθ aperture
QCAL = the quantized calibrated pixel value in DN
$LMIN_\lambda$ = the spectral radiance that is scaled to QCALMIN
$LMAX_\lambda$ = the spectral radiance that is scaled to QCALMAX
QCALMIN = the minimum quantized calibrated pixel value
QCALMAX = the maximum quantized calibrated pixel value

$$\rho_\rho = \frac{\pi \cdot L_\lambda d^2}{ESUN_\lambda \cdot \cos\theta_s} \quad (2)$$

ρ_ρ = Unitless planetary reflectance
L_λ = Unitless planetary reflectance
d = Earth - Sun distance in astronomical units
$ESUN_\lambda$ = Mean solar exoatmospheric irradiances
$\cos\theta_s$ = Solar zenith angle in degrees

(http://ltpwww.gsfc.nasa.gov/IAS/handbook/handbook_htmls/chapter11/chapter11.html)

Topographic Correction

91 samples collected from ETM+ image are used for correction in forest fire burnt. The left-side term (Log L cos e) and the second part of right side(Log cos i cos e) in equation (3) could be derived from 91 sample in forest fire area(Lee et al., 1997).

$$\log(L\cos e) = \log L_n + k\log(\cos i \cos e) \quad (3)$$

L: sensor recorded radiance i: incidence angle
L_n: normalized radiance k: Minnaert constant
e: slope

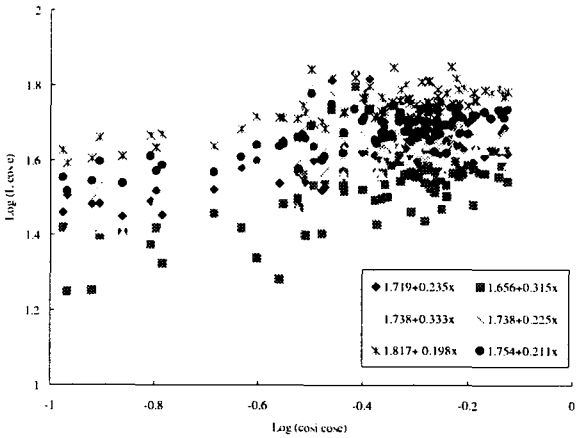

Figure 2. Empirical derivation of the Minnaert constants *k*

The Minnaert constants k for forest fire burnt applied to each bands of ETM+ data. As shown Figure 3, topographic correction is appeared good result in visual interpretation and helps to reduce of errors for classification in mountainous area.

Table 1. The Minnaert constants *k* derived from area of forest fire burnt

	Landsat 7 ETM +					
Band	Band 1	Band 2	Band 3	Band 4	Band 5	Band 7
λ(㎛)	0.45-0.72	0.52-0.60	0.63-0.69	0.76-0.90	1.55-1.75	2.08-2.35
K	0.235	0.315	0.336	0.224	0.198	0.211

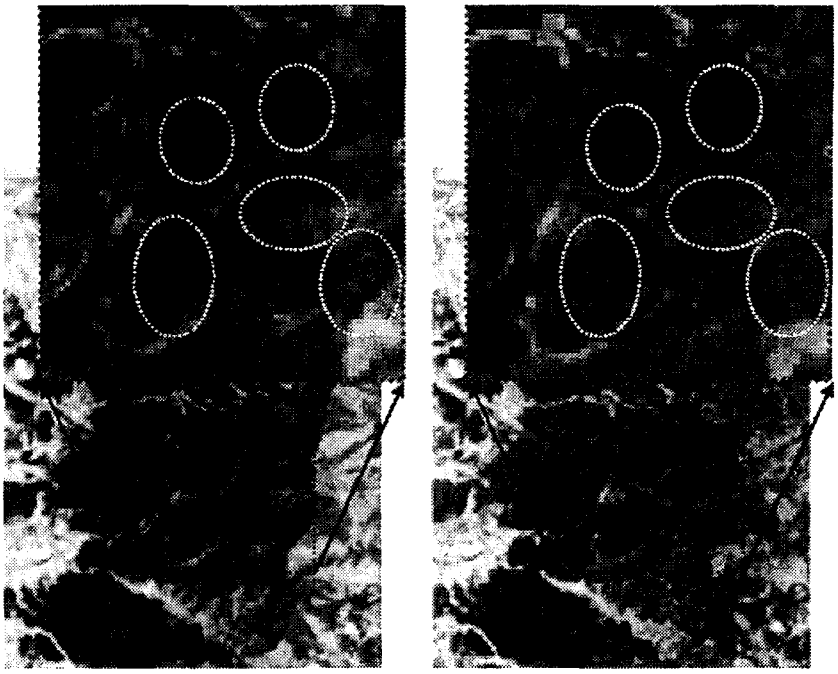

Figure 3. Topographic corrected ETM+ image(right) uncorrected raw ETM+ image(left)

Supervised classification performed by MLC (Maximum Likelihood Classification) and the thematic map composed of 5 classes (Forest fire damaged, Forest, Water, Urban, Bare). Then kappa statistics were derived (table 2) for accuracy assessment of classification map.

Table 2. Kappa statistics from classifying sampled test pixels

Class	Forest fire burnt	Forest	Water	Urban	Bare soil
Kappa statistics	0.88	0.86	0.78	0.74	0.68

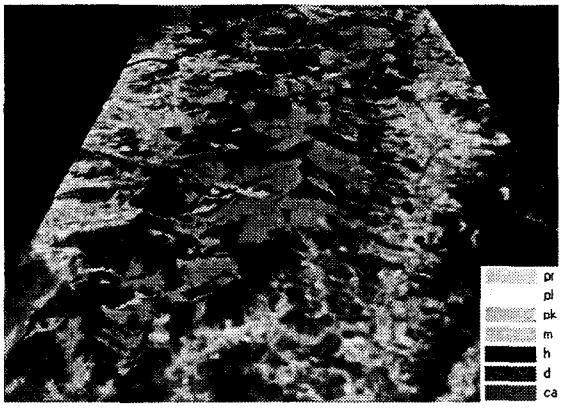

Figure 4. 3D ETM+ image overlaid by digital map of forest fire burnt in each forest stand types

4. Results

Table 4 shows that results of forest fire damage in each forest. The moderate damage class sets aside 52% of whole area and D(*Pinus Densiflora*) forest stand has more severe damage than other forest stands. This results show tendency that follow in ration originally of forest stand types.

The forest stand type D has low percentage in severe damage class and Deciduous forest (CA) has higher

Table 3. Descriptions for code of each forest stand types

Code	Full (Species) name
PR	*Pinus Rigida*
PL	*Larix Leptolepis*
PK	*Pinus Koraiensis*
M	Mixed Forest
H	Deciduous Forest
D	*Pinus Densiflora*
CA	*Castanea Crenata*

Table 4. Results of forest fire burnt in each forest stand types

Damage Class		Forest Stand Types						
		PR	PL	PK	M	H	D	CA
Light	Area(ha)	540.0	52.5	470.3	843.2	589.9	6069.9	6.9
	%	6.3	0.6	5.5	9.8	6.8	70.4	0.1
Moderate	Area(ha)	704.2	101.0	341.3	1498.8	848.6	15867.4	25.9
	%	3.6	0.5	1.7	7.7	4.3	81.3	0.1
Severe	Area(ha)	748.1	255.1	86.3	2992.3	1235.8	4224.1	11.8
	%	7.7	2.6	0.9	30.8	12.7	43.5	0.1

percentage in severe damage class. The Coniferous forest (D, PR, PL) is occupied higher percentage of forest fire burnt more than Deciduous forest.

5. Conclusions

Minnaert correction is proper method to reduce bidirectional shadow effects for mountainous area. It is effective to reduce errors of classification. In results of this study we know that forest stand type D(Pinus Densiflora) has more damaged than Deciduous forest.

It is expected to present selection of tree species planted for restoration of forest fire damage area. But it should be executed to analyze for ratio forest fire burnt to existence forest. This research will apply to high resolution imagery(IKONOS and QuickBird satellite data).

Acknowledgements

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