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DETERMINATION OF CRITERIA FOR BURNED AREA IDENTIFICATION IN NIZHNEE PRIANGARYE TERRITORY USING GIS

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ABSTRACT: The damage of Nizhnee Priangarye forests was analyzed in this work using high resolution remote sensing data received from "Landsat" and "Resource" satellites. The processing was performed with the help of "ERDAS IMAGIN 8.4" Geo Information System. The suitability of Landsat imagery for damaged forest mapping was ascertained.

KEY WORDS: remote sensing, GIS, classification, burned area, felling area

INTRODUCTION

An important role in formation of the present-day appearance of Nizhnee Priangarye forests along with felling and silkworm outbursts is attributed to wildfires. They are natural and extremely significant factor influencing boreal ecosystems and processes taking place inside them. Fire disturbance could be considered one of the main reasons of succession processes.

Also one should not leave out of account the impact of the commercial felling on the forests of the investigated region, for the territory is a zone of intensive forest exploitation. Since the early 60-s of the past century lumbering has been carried out here. As a consequence of this there accumulate crucial amount of forest fuel all over the cutting areas in the form of felling debris. Thus a great deal of forest fires occur just in locations of industrial lumbering sites.

Taking into consideration all the above mentioned facts, the primary objective of the present work consists in estimation of how heavily the investigated region was affected both by wildfires and felling.

MATERIALS AND METHODS

"Landsat" and "Resource" imagery, ground measurements and forest husbandry data were used for analysis of the investigated territory.

Two adjacent Landsat-7 scenes dated August, 18 and 27 2000, Landsat-5 scene dated 1990 and photo images obtained from “Resource” satellite in 1985 and 1986 were chosen for the work.

In September, 2002, we accomplished ground measurements of several burned areas within studied region. The purpose of the measurements was to describe main features of the areas, damaged by wildfires in 1996 and 2002. Table 1 represents the values of Landsat-7 relative spectral brightness for the investigated field sites.

On having analyzed the table we came to a conclusion that Landsat-7 channels 4, 5 and 7 are more useful for sound and damaged vegetation separation.

Table 1

Site number	*Site type*	**Values of relative spectral brightness, Landsat 7 channels**					
		1	**2**	**3**	**4**	**5**	**7**
1/2/1	sparse lichen pinery	60	46	42	71	50	29
5/10	sparse young stands, 2002 burn	58	45	41	78	77	43
1/2/2	young lichen pine stands	57	42	33	60	42	25
3/16	unburned young growth	53	39	31	76	43	21
5/9	sparse young stands	55	45	38	86	66	36
5/6	1996 burned area	54	41	36	62	65	41
5/7	2002 burn on 1996 burned area	57	42	40	57	72	45
5/8	2002 burn on a logged site	58	43	42	58	73	46
5/11	1996 burned area	65	47	42	63	57	37
3/12	1996 burned area	64	50	54	67	81	52
3/13	1996 burned area	60	47	47	70	78	47
3/14	1996 burned area	60	45	45	73	66	39
3/15	1996 burned area with dead fallen trees	58	43	42	55	64	42
3/17	1996 burned area with dead fallen trees	60	43	42	60	72	47
3/18	1996 burned area	57	42	40	51	56	38
Average values for sound vegetation		56,6	43,4	37	74,2	55,6	30,8
Average values for burned areas		59,3	44,3	43	61,6	68,4	43,4
Absolute difference between the average values		2,7	0,9	6	12,6	12,8	12,6

Ground measurements were carried out only for burned areas. For the definition of other types of ground cover the forest husbandry data was used. Eventually, all the main classes for the region were defined. For each such class 20 control points within studied region were predefined. The average and standard deviation values of every class for each spectral channel were calculated (fig. 1).

As you can see in this diagram, maximum separation of disturbed and sound vegetation is observed in channels 3, 5 and 7. Moreover, the shape of damaged vegetation curves differs from that of sound vegetation curves. Maximums of the curves typical for sound vegetation are in Landsat channel 4, whereas those typical for damaged vegetation fall on the 5-th channel. Sound and damaged vegetation types have nearly the same values in channel 4, but damaged vegetation has higher characteristics in the 3rd, 5th and 7th channels. Channels 1 and 2 are suited best for identification of urban areas. Water bodies are separate objects in channels 4, 5 and 7.

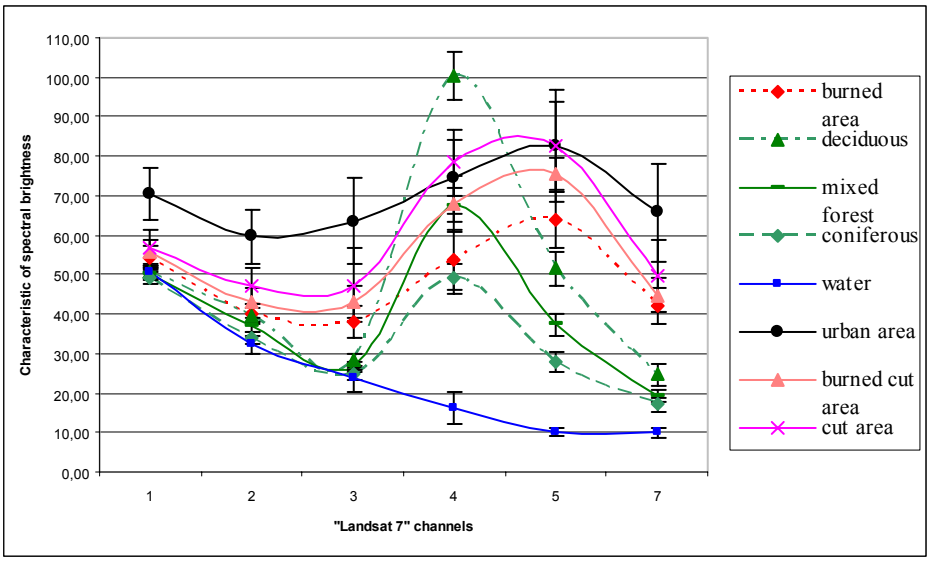

Fig. 1. The spectra of dominant classes defined over the Landsat image

For all the described classes “spectral signatures” were generated in GIS “ERDAS”. This “spectral signatures” were used as training samples for imagery classification using the maximum likelihood method.

The methodology of the processing consists of the following stages:

1. Primary processing
   - Analysis of the investigated territory and available data, and the definition of dominant classes of reflecting surface. In the course of this analysis “Landsat-7” imagery was compared with ground-based measurements and forest husbandry plans. As a result 7 dominant classes were defined: burned areas, felling areas, deciduous, coniferous and mixed forest, water bodies and urban areas.
   - Formation of a training sample for each class.
   - Generation of “spectral signatures” for all classes on the basis of these training samples using data from all “Landsat-7” spectral channels.
   - Preparation imagery for the next processing (exclusion of clouds).
   - Geographic correction of the imagery.

2. Classification
   - Classification of “Landsat-7” imagery with the help of the maximum likelihood method using the acquired “spectral signatures” as training samples (fig.2).
   - Calculation of a total area for each class.

For one small part of the studied territory we outlined felling areas using “Resource” photo images received in 1985 and 1986. Afterwards the polygons of the felling areas were overlaid on the Landsat-5 image and Landsat-7. Every time new polygons were added. In the end all the outlined felling area polygons were compared with the classified Landsat-7 image. As a result we found out that about 90% of areas felled in 1985 and earlier and 40% of areas felled in 1986 are presently occupied by deciduous stands. Coniferous and mixed stands are known to be typical for the investigated territory. Also it should be noticed that deciduous stands are interchangeable species. Taking into account all these facts we may conclude that areas occupied by deciduous stands at the present time were damaged by felling or fire several decades ago.

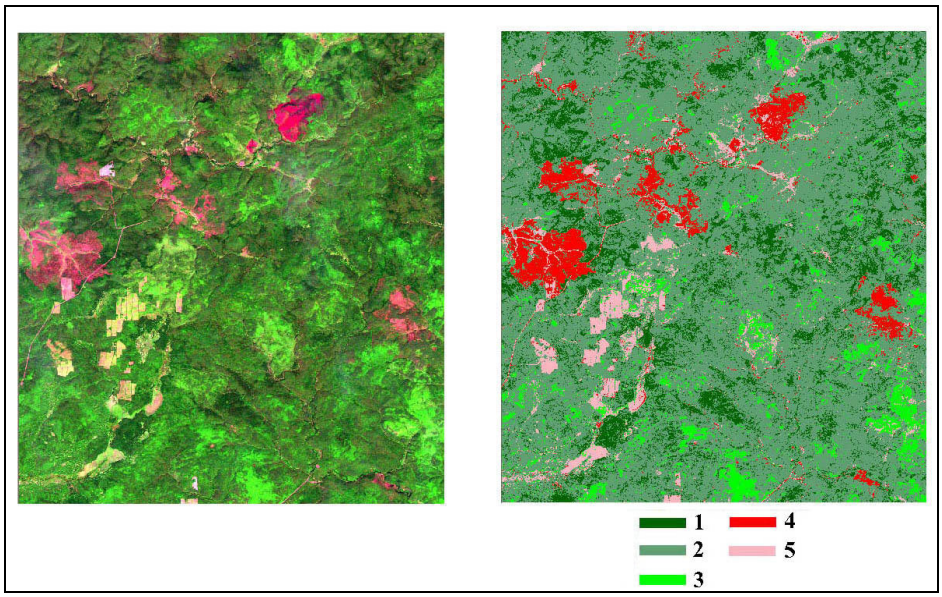

Fig. 2. A fragment of original Landsat-7 image (on the left), and the results of the classification by means of the maximum likelihood method using training samples (on the right)

RESULTS

A total area for each class obtained in the result of the classification was calculated. They made up: coniferous (P, L, F, S, C) – 19,0%, mixed forest (mainly B, A, P, L) – 43,8%, deciduous (B, A) – 14,9%, burned areas – 7,6%, cut areas and other deforested territories – 13,4% and water surface – 1,4%.

Employing the supposition that territories under deciduous stands may be considered disturbed by fire or cut a few decades ago we subdivide the whole territory into 2 main

classes: undisturbed (coniferous and mixed stands – about 63%) and disturbed (burned areas, cut areas and deciduous stands – about 36%).

Consequently, nearly 40% of forested area over the investigated territory was impacted during the last 30–40 years.

CONCLUSIONS

The results of the field investigations concerning burned areas in Boguchany region have led to the following inferences:

- In stands affected by surface fire accumulation of combustible materials takes place in the form of grass, shrubby layer and the trunks of falling dead trees. Which in its turn favors a recurrence of fire.
- Falling of dead stands goes on during prolonged intervals of time periodically forming crucial storages of combustible materials and contributing to repeated occurrences of fires over the same particular territory. These fires result in destruction of young stands and delay in the forest regeneration process.

Inferences concerning the classification of "Landsat 7" imagery:

- The best channels of "Landsat 7" for separation of sound and damaged vegetation are channels 3, 5 and 7. Maximal separation of the classes is observed in channel 7, the standard deviation being minimal. Maximums of the curves typical for sound vegetation are in "Landsat 7" channel 4, whereas those typical for damaged vegetation fall on the 5^{th} channel.

In conclusion it must be noticed that the achieved results allow considering Landsat-7 data as effective means for disturbed forest area monitoring.

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